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# CHEMICAL INVESTIGATION OF SALIVARY CALCULUS

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As an extension of a systematic study of the composition of dental tissues (1, 2), the chemical composition of salivary calculus has been investigated. Before proceeding to give the results of our own chemical analyses, which have been supplemented by an X-ray crystallographic analysis and spectrographic analysis for trace elements, a short review of past work and current ideas on the relevant aspects of the subject will be reported.

One point on which there is a diversity of opinion is the existence of different types of salivary calculus. This was of importance in the connection with the collection of material. Burchard (3, 4) stated that there were 5 types of calculus corresponding to different pathological conditions. It appears, however, that the generally accepted teaching on the subject is that there are 2 types: (1) Salivary calculus, deposited from the saliva, which is yellowish, soft and friable and occurs above the free gum margin, chiefly on the buccal surfaces of upper molars and lingual surfaces of lower incisors, i.e. in relation to the salivary ducts; (2) Serumal calculus, consisting of hard dark crusts, very strongly adherent to the teeth, which is deposited subgingivally and originates from exuded serum (5). Although this type is also frequently found above the free gum margin, it is always deposited subgingivally and only exposed as a result of gum recession. Black (6, 7) considered all calculus to be serumal in origin, while Kirk (8) thought it all salivary in origin, the type depending on the amount of mucin in the saliva. Naeslund (9, 10), who considered that salivary calculus was formed as a result of the action of microorganisms, found all calculus very similar histologically. Another view is that of Prinz (11, 12, 13) who stated that there was no standard type of calculus, that it is white and soft when first deposited and later hardens and becomes dark by admixture with debris and decom-

posed blood (presumably haemin derivatives), chromogenic bacteria and tobacco stain. All calculus is, according to him, salivary in origin.

The salivary calculus used by us in this investigation has been removed from permanent teeth of all types and has been dark greenish grey in colour, very hard and all of subgingival type. In a number of cases we removed and analysed pieces of calculus from separate teeth. The average weight of these pieces was 15 mg, which gives some indication of the size of the deposit.

## COMPOSITION OF SALIVARY CALCULUS

The results of previous investigators all corroborate the view that calculus is mainly inorganic, the chief constituent being calcium phosphate, and that it also contains a certain amount of protein. Some of the more complete quantitative analyses are given in Table I. The study by Karshan and Schroff (14), on gland and duct calculi, has, so far, been the most systematic and in view of the amount of material used probably the most reliable. In the present investigation we had in mind 2 chief points;—(1) to see if there is any constancy of calculus from different teeth, by analysis of single tooth samples and (2) to make a careful quantitative analysis by the methods which have been previously applied in this laboratory to enamel and dentin, of pooled samples of calculus from numerous teeth.

The source of the material was the collected extractions from several large dental hospitals. The selected teeth were taken on the day of extraction, rinsed in water and then placed in 95 per cent ethyl alcohol for about ½ hour. (This procedure would dissolve neither inorganic nor organic material.) The gingival tissue was removed by scraping and the tooth cleaned up all round the deposit which was then removed as a single piece with a scalpel. When collecting single tooth samples, these were dried and weighed on a sensitive torsion balance. When pooled samples were used, calculus was removed from teeth until about 0.5 g. had accumulated. For the inorganic quantitative analysis, this was ground to a fine powder, extracted with warm water, then with acetone and finally dried to constant weight at 100°C. The powdered tartar was a light greenish grey in colour. It was not completely soluble in either dilute nitric or hydrochloric acids and

for this reason the samples were fused with about 10 times their weight of sodium carbonate and then dissolved in 10 per cent HCl. The quantitative analyses for Ca (18), P (19) and Mg (20) were carried out on this acid solution. The estimations of ash, $CO_2$ (by the method of Van Slyke), nitrogen (by a micro- Kjeldahl) fat by ether extraction and iron were performed directly on the untreated material.

TABLE I

*Previous analyses of salivary calculus**

| WORKER | TYPE OF CALCULUS | ORGANIC | ORGANIC + WATER | CaO | $CO_2$ | $CaCO_3$ | $P_2O_5$ | Ca PHOSPHATE | Mg PHOSPHATE |
|---|---|---|---|---|---|---|---|---|---|
| | | per cent | per cent | per cent | per cent | per cent | per cent | | per cent |
| Schuh (11, 12)..... | | | | 39.91 | 5.34 | | 30.45 | | |
| Prinz (11, 12)..... | Salivary | 15.16 | 20.88 | | | 9.14 | | 63.42 | 1.31 |
| Stevenson (15) | (a) Soft on molars | | 21.48 | | | | | 77.21 | 1.31 |
| | (b) Hard on incis. | | 17.51 | | | | | 81.18 | 1.31 |
| Scheheotskey (15)... | | | 22.07 | | | 8.13 | | 67.18 | 1.07 |
| Salisbury (15)..... | Serumal | | 32.24 | | | 3.70 | | 63.08 | 0.98 |
| Hulin (16)..... | | 26.43 | 30.53 | | | | | | |
| Malenfant (15)..... | | | | | | | | 27 Basic 60 | 1 |
| Philipp (17)..... | Yellowish | 25 | | 51.48 | 0.28 | | 47.04 | | |
| Karshan and Schroff (14)..... | Submax. duct | 22.5 | | | 1.99 | 4.52 | | 68.0 | 2.0 |
| | Submax. duct | 22.7 | | | 1.68 | 3.82 | | 70.5 | 1.97 |
| | Submax. duct | 28.4 | | | 1.38 | 3.14 | | 66.7 | 1.46 |
| | Submax. duct | 13.5 | | | 2.39 | 5.43 | | 79.6 | 1.12 |
| | Submax. gland | 12.9 | | | 2.09 | 4.75 | | 78.1 | 1.16 |

* In addition to the figures given above, Prinz gives 5.24 per cent water soluble substances, Scheheotskey 1.56 per cent $CaF_2$ and Malenfant 4 per cent alcohol and HCl.

The iron was determined by the colorimetric method of Hill (21), using the preliminary procedure advised by Engel (22). In order to eliminate any iron present as a contamination in the form of haematin derivatives, the calculus was first extracted with NaOH as described by Rantner (23).

*Results of qualitative tests.* Elements, groups and substances detected:—Ca, Mg, Fe, Na (trace), phosphate, carbonate, nitrogen,

protein (Xanthoproteic and Millon), fat, sulphur, free cystine and perhaps thiocyanate. Free cystine was tested for by the colorimetric method of Folin and Marenzi (24) and a positive result obtained. It was thought advisable to test whether thiocyanate gives this test, since it is a universal constituent of saliva, and it was found that it did. Since the substance in tartar giving this test was soluble in dilute sulphuric acid and not in water, it is probably free cystine. There could, therefore, be no more than a trace of thiocyanate present. Ether extraction demonstrated the presence of fatty material, solid at ordinary temperatures. This material contained only a trace of P and hence must be neutral fat and not phosphatide. Substances not detected;—Calcium oxalate (found by Badanes, (25) and cholesterol (found by Adamson, (26, 27) in serumal calculus.

*Protein present in calculus.* Protein was detected by the Xanthoproteic and Millon's test. Using Cole's (19, 28) modification of the Millon test it was shown that there were present acid insoluble particles, giving a good positive test for tyrosine. This, coupled with the detection of cystine, gives definite evidence for the presence of keratin, the origin of which is, no doubt, the epithelial scales. Further evidence for the presence of keratin was afforded by the demonstration of the existence of protein, insoluble in dilute alkali, dilute and strong acids, but soluble in hot strong alkali, and also undigested by pepsin. Furthermore, decalcified sections of calculus stained by Mallory's method indicated the presence of keratin. Mucin was also shown to be present in these sections by Mallory's stain and by mucicarmine. A dilute alkali extract of calculus, after acid hydrolysis, gave a strong P test, indicating the presence of organic P, which in the absence of lipoid P, indicates nucleic acid derived from nucleoprotein. Nucleic acid or nucleoprotein has been shown to be present in many types of micro-organisms (29), and bacteria have been shown by Bulleid (30) and others and actinomyces by Naeslund (9–10) to be present in all samples of tartar examined. The proteins of calculus, representing the fraction of tartar insoluble in 10 per cent HCl (by volume) therefore probably consist of keratin, nucleoprotein and mucin.

*Solubility of calculus.* Calculus is a remarkably insoluble substance as is shown by the fact that it is not completely soluble in dilute or concentrated HCl, $HNO_3$ or acetic acid, dilute alkali, dilute

acid followed by dilute alkali and is only completely dissolved by the action of strong hot alkali followed by dilute or concentrated acid. This is to be explained by the fact that the inorganic constituents are soluble in dilute acids and the organic in hot, strong alkalis.

*Results of spectrographic analysis.* In addition to the major elements already detected chemically, the following were shown to be present by spectrographic analysis. Those present in small amounts included Cu, Ag, Na, Sn and those in very small amounts included Pb, Zn, Al, Ba, Si, Sr.[1] A trace of Cr was also detected. It must be remembered that the terms "small amount" etc., refer to amounts which would be difficult to detect and estimate chemically.

*Analysis of single tooth samples.* Since a complete quantitative analysis was impracticable on the amount of material obtained from one tooth, we decide to estimate the Ca and P only and so by calculating the Ca/P ratio determine whether the inorganic part showed any constancy of composition. The Ca/P ratios calculated form the results obtained for 23 single tooth samples are as follows:—1.83, 1.84, 1.70, 1.75, 1.89, 1.67, 1.92, 1.95, 2.05, 1.81, 1.66, 1.97, 1.71, 1.75, 1.76, 1.80, 1.84, 1.90, 1.88, 1.95, 1.75, 1.76, 1.80, 1.84, 1.90, 1.88, 1.95, 1.75, 1.84, 1.87. The average of these is 1.83.

Although these ratios show considerable variations, they do indicate that the chief inorganic constituent must be some form of calcium phosphate. Calcium phosphate $Ca_3(PO_4)_2$ gives a Ca/P of 1.935 and apatite, 3 $Ca_3(PO_4)_2$. $CaX_2$ a ratio of 2.153. The average of our ratios is higher than that of Philipp (17), who found a Ca/P ratio of 1.79 and yet considered, without comment, from the results of X-ray analysis, that calculus is an apatite.

*X-ray crystallographic analysis.* This analysis was undertaken by J. Thewlis, of the National Physical Laboratory, who reported that the X-ray diffraction photographs were weak, suggesting the occurrence of a certain amount of amorphous material. The size of the crystalline particles was very small. The lines suggested a structure similar to that of apatite, but the lattice dimensions differed considerably from those of any of the apatites previously examined i.e. fluor and several samples of hydroxyapatite, and in this way the

[1] The meaning of the terms "small" and "very small" amounts can be gained by reference to previous work of Lowater and Murray (31).

results do not confirm those of Philipp (17) who reported characteristic hydroxyapatite patterns, which is surprising because of the weakness of the diffraction photographs.

Bredig et al. (32) showed that precipitated calcium phosphate is always in the form of hydroxy-apatite, and this fact, taken in conjunction with the results of X-ray analysis, rather suggests that salivary calculus may not be formed by a straightforward precipitation but, as Naeslund suggests, as a deposit due to bacterial or other microbic action in the stroma of the vegetation of micro-organisms. It would be of interest to examine by this method the artificial deposits of "tartar" which Adamson (27) was able to obtain on threads placed in saliva containing gingival tissue.

TABLE II

*Composition of salivary calculus*

| SAMPLE | Ca | P | Ca/P | Mg | Fe | $CO_2$ | N | FAT |
|---|---|---|---|---|---|---|---|---|
| | *per cent* | *per cent* | | *per cent* | *per cent* | *per cent* | *per cent* | *per cent* |
| A..... | 30.55 | 17.27 | 1.765 | 1.05 | | | | |
| B..... | 31.17 | 16.76 | 1.856 | | | | | |
| C..... | 31.47 | 17.34 | 1.826 | 0.967 | | | | |
| D..... | 30.60 | 16.77 | 1.824 | 1.066 | | | | |
| E..... | 29.82 | 16.21 | 1.840 | | 0.0196 | 1.393 | 1.335 | 2.7 |
| *Average*..... | 30.72 | 16.85 | 1.822 | 1.044 | | | | |

*Quantitative analysis of pooled samples.* Five of these pooled samples, A, B, C, D and E were analysed. The results are given below (Table II). Each sample represented several hundred teeth, e.g. 500 teeth were used for sample E. The analyses were carried out in all cases in triplicate or until constant results were obtained. The fact that only one set of figures is given for N, $CO_2$ and Fe does not restrict their value, since the sample used must be an average sample and the value recorded is the mean of several determinations.

From these chemical and crystallographic results, it was considered reasonable to calculate the percentage composition of calculus along the following lines. All the $CO_2$ was calculated as $CaCO_3$, the residual Ca as $Ca_3(PO_4)_2$ and the Mg as $Mg_3(PO_4)_2$. The residual P must be present in organic combination, probably in the form of nucleoprotein. The loss on ashing to constant weight in a muffle

furnace was found to be 18.48 per cent which includes $CO_2$, organic matter and combined water. This leaves 81.52 per cent ash, a value between that of enamel and dentine. Reference should be made to Table I under the column "Organic + $H_2O$" for the values obtained by other workers for the loss on ashing. Most observers have found approximately 80 per cent ash, dentine has 70 per cent ash (1).

The addition of these so exactly to 100 is accidental for there exist small amounts of other metals, e.g., Fe and those detected spectroscopically. As previously stated a small amount of residual organic phosphorus is not included. The agreement between the calculated composition of the inorganic part and the sum of the determined ash and $CO_2$ is remarkable.

TABLE III

*Composition of salivary calculus*

| DETERMINED | | CALCULATED COMPOSITION | |
|---|---|---|---|
| | *per cent* | | *per cent* |
| Ash | 81.52 | Inorganic: | |
| $CO_2$ | 1.39 | $CaCO_3$ | 3.17 |
| Protein | 8.34 | $Ca_3(PO_4)_2$ | 75.97 |
| Fat | 2.71 | $Mg_3(PO_4)_2$ | 3.77 |
| Total | 93.96 | | 82.91 |
| ∴ Water and other organic substances | 6.04 | Protein | 8.34 |
| | | Fat | 2.71 |
| | | Water etc. | 6.04 |
| | | | 100.00 |

## SUMMARY

1. A study has been made of the inorganic and organic material of salivary calculus. 2. The inorganic material (82.9 per cent) is made up of calcium and magnesium phosphates (79.7 per cent) and calcium carbonate (3.2 per cent). 3. There is 8.34 per cent protein present. This is found to consist of keratin, mucin and nucleoprotein (or nucleic acid). There is also 2.7 per cent fat. 4. Spectrum analysis revealed the presence of small amounts of Cu, Ag, Na, Sn and traces of Zn, Al, Ba, Sr and possibly Cr. 5. X-ray crystallographic analysis gave poor results. Salivary calculus is largely amorphous, though probably in part "apatite" like in structure.

The spectrographic analysis mentioned in the text was kindly done for us by Professor H. Dingle of Imperial College of Science and Technology London. We wish to thank the Medical Research Council for a grant for expenses and for a personal grant to G. E. G. We also gratefully acknowledge our thanks to Dr. P. Pincus of the Royal Dental Hospital London for supplying material and for his advice.

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# DETERMINATION OF PERCENTAGE OCCURRENCE OF VARIOUS GROUPS OF MOUTH BACTERIA[1]

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The relative frequency of occurrence of different groups of microorganisms in the mouth has never been definitely established. Previous studies of the oral flora have employed cultural methods which, because of the inherent selectivity of all cultural procedures and their general unsuitability for the mouth bacteria, have failed to give a true picture of the constituent parts of this complex flora. The extent of the distortion incurred in cultural studies of the oral flora is indicated by Kligler (1915) whose studies showed that the totals of microorganisms appearing in aerobic and anaerobic mouth cultures were sometimes only 0.5 per cent of the number of bacteria observed by microscope counts. It is obvious, therefore, that it is desirable to establish a method which will give reasonably accurate estimates of the percentages of different microorganisms in such specimens. In view of our poor knowledge of the cultural properties of the oral bacteria it seems that the greatest prospect of success lies in a method of direct smear examination. As yet, however, no methods have been described for making differential morphological counts of mouth bacteria. This paper records the development and application of such a procedure. Subsequent papers will report its application in various fields.

Since mouths and teeth have different surface areas and vary in their capacity for retaining bacteria-containing debris the total number of microorganisms in the mouth has little bacteriological significance. Similarly, the unknown dilution factors caused by the variable secretion of saliva make meaningless the numbers of bacteria in a unit amount of a mouth specimen. Therefore, it seems that the only sig-

[1] The study upon which this report is based was made possible by funds granted by the Carnegie Corporation of New York.

FIG. 1. Typical counting field showing cluster of Gram-negative bacilli, few Gram-positive diplococci, several larger Gram-positive cocci, Gram-negative fusiform bacilli (probably *Fusiformis polymorphus*) and irregularly stained Gram-positive filament. (× 1100)

FIG. 2. Heavy smear showing faintly stained Gram-negative fine fusiform organisms. Irregularly stained fine and thick Gram-positive filaments can be seen, together with Gram-positive and Gram-negative cocci and occasional Gram-positive and Gram-negative bacillus. (× 1000)

FIG. 3. Smear showing at left 2 large fusiform bacilli (*Fusiformis dentium*) one with typical granular staining. At lower right is group of Gram-negative filaments (probably decolorized *Leptotrichia buccalis*). About the large Gram-positive filament Gram-negative small bacilli, fine fusiform organisms and short filament can be seen. (× 900)

FIG. 4. Smear showing central Gram-negative filament, Gram-positive fusiform bacilli, and vibrios. (× 1000)

FIG. 5. Gentian violet-stained smear showing granular thick fusiform bacilli, filaments, one with pointed end, spiral organisms, cocci, and bacilli. (× 1100)

nificant bacterial measurement which can be made is a determination of the percentage occurrence of different types of microorganisms without regard to the absolute numbers of bacteria.

*Development of Method.* If, as is assumed in all bacteriological procedures, aliquot samples are representative of the original flora, the microorganisms in microscope fields of stained smears should be present in the same proportions as they were in the original sample. If various types of microorganisms can be distinguished in smears it should be possible to establish their relative percentage occurrence by differential smear counts. To determine the possibility of making reliable estimates of the percentages of a variety of bacterial species series of repeated counts were made of different types of organisms in Gram-stained smears prepared from mixtures of pure cultures or from mouth specimens. In these preliminary observations it was found that if more than 200 organisms were counted, close duplication of the percentages was obtained, except in the percentages of Gram-positive and Gram-negative cocci. Subsequent tests showed that these irregularities could be overcome if a careful differentiation of the Gram-reaction was made by critical focusing and adding to each slide a control smear of *Staphylococcus aureus* and *Escherichia coli* to serve as a measure of the intensity of the stain. By further tests it was also demonstrated that reproducible results could be obtained with any arbitrarily chosen groupings of bacteria by the use of Ljubinsky, iodin or Tunnicliff's spirochete stain, within reasonable limits, in thin as well as thick smears and regardless of whether smears were prepared directly from the mouth or after much shaking in suspension. On the basis of these observations and without regard to basic mathematical considerations the following method was adopted to determine the percentage distribution of different types of microorganisms in material taken from the mouth.

## METHOD

*Preparation of Smears.* When saliva or mouth washings were being studied, a portion was taken from the container in a capillary pipette and smeared over a large area of a clean slide. If the material contained masses of organisms, it was transferred, on the dental instrument on which it was taken, to a wide tube containing glass beads and 1 cc. of a diluent. After shaking thoroughly for 2 minutes, the suspension was smeared by the method used above. Until characteristic Gram-positive and Gram-negative oral microorganisms were recognized, a mixed smear of 18 hour cultures of *Staph. aureus*

and *Esch. coli* was made on each slide. The smears were allowed to dry in a covered place.

*Staining.* Routinely smears were stained by Gram's method, using Hucker's gentian violet (one-half minute) and counterstaining with safranin. Occasionally, duplicate smears were stained with Ljubinsky's or iodin stain.

*Counting.* In making counts, the various types of organisms were divided into arbitrary groups. A basic division into both Gram-positive and Gram-negative cocci, bacilli, filaments, vibrios, and fusiform organisms was made. As our knowledge of the morphology of the oral microorganisms increased, it was desirable to use different subgroupings, or to modify them for the particular purposes of the studies. For instance, the fusiform organisms, which at first were divided into four types, Gram-positive, large and small, and Gram-negative, large and small, were later divided into three groups, Gram-positive to negative thin, Gram-positive to negative thick, and Gram-negative short, which corresponded with the three recognized cultural groups. Thus, although the morphological groups were not always the same, they were identical in any given series of determinations. With a chosen classification in mind, a preliminary viewing of the slide was made for about 5 minutes or until a definite impression of the approximate distribution of organisms throughout the smear was obtained. Thereafter, from 8 to 10 fields, which appeared representative of this distribution, were chosen and examined until a total of about 250 organisms had been counted. The figures obtained for each group of microorganisms were then expressed as percentages of the total number of bacteria counted. Counting fields in which the morphological types estimated at various times can be recognized are shown in *figs.* 1–5.

*Accuracy of Method.* To test the accuracy of the method the results obtained in pairs of duplicate counts were compared. The duplicating count of each pair was made at periods of from 1 day to 5 weeks after the original count, on the same smears or on different smears from the same source and, in many instances, without the examiner knowing the method was being tested. Two series, each of 10 such duplicate counts, were compiled. One (Table I) was made using the original grouping of organisms and the other (Table II) was made 6 months later when a modified basis of classification was being employed. Differences between the percentage occurrence of various types of organisms in the duplicate counts vary all the way from 0 to 11.1. The size of these differences, however, may be seen to be related to the magnitude of the percentages. For example, at percentage ranges below 2.5 two thirds of the differences are less than unity, whereas at percentage ranges of from 5 to 10 more than three quarters of the differences are greater than unity. From a tabulation (Table III) grouping the differences found between the duplicate counts at various ranges of percentage occurrence (average of duplicates) the average differences between the 2 counts were calculated. These averages represent the expected experimental errors at various percentage ranges. This sort of variation is predictable if a suitable number of organisms are counted. Thus, Barnett (1933) in a comparable analysis of 200 blood elements observed variations of from 1 to 4 with percentage occurrences of 2.5 to 5.0. His variations are given in the form of a curve from which interpolations have been made for the purpose of comparison. In Table IV his interpolated standard deviations and the probable distribution of percentages calculated according to Poisson's rule are compared with the average experimental errors derived from Table III.

The comparable sizes of our experimental errors and the theoretical probable distributions of organisms shown in the table indicate the soundness of the experimental pro-

TABLE I

*Comparison of the Frequency of Occurrence of Organisms, Determined in Duplicate Estimates of Numbers of Organisms in Smears*

| SERIES | SOURCE | NO. OF ORGANISMS COUNTED | PERCENTAGES OF TOTAL ORGANISMS COUNTED | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Filaments | | | | Fusiforms | | | | Cocci | | Bacilli | | | |
| | | | Gram pos. | | Gram neg. | | Gram pos. | | Gram neg. | | Gram pos. | Gram neg. | Gram pos. | | Gram neg. | |
| | | | L | S | L | S | L | S | L | S | | | L | S | L | S |
| A | Buccal mucosa | 210 | 1.7 | 6.0 | 0.8 | 2.5 | | | | | 69.8 | 17.2 | — | — | — | 1.7 |
| $A_1$ | | 321 | 1.7 | 5.6 | 4.0 | 1.7 | | | | | 68.2 | 16.2 | — | — | — | 2.4 |
| Diff. | | | 0 | 0.4 | 3.2 | 0.8 | — | — | — | — | 1.6 | 1.0 | — | — | — | 0.7 |
| B | Gingival pocket | 225 | — | 2.5 | 4.0 | 5.6 | | | | | 51.2 | 31.2 | — | 2.3 | — | 3.2 |
| $B_1$ | | 258 | — | 3.3 | 4.9 | 5.7 | | | | | 45.1 | 34.7 | — | 2.9 | — | 3.1 |
| Diff. | | | — | 0.8 | 0.9 | 0.1 | — | — | — | — | 6.1 | 3.5 | — | 0.6 | — | 0.1 |
| C | Carious cavity | 249 | — | 2.0 | 2.6 | 2.3 | | | | | 43.6 | 38.5 | 6.7 | — | — | 4.0 |
| $C_1$ | | 243 | — | 2.0 | 3.4 | 4.1 | | | | | 45.2 | 33.8 | 6.3 | — | — | 5.5 |
| Diff. | | | — | 0 | 0.8 | 1.8 | — | — | — | — | 1.6 | 4.7 | 0.4 | — | — | 1.5 |
| D | Lower molar | 204 | 2.8 | 1.9 | 9.6 | 4.8 | 0.9 | — | — | — | 22.7 | 46.1 | — | 0.9 | — | 9.6 |
| $D_1$ | | 210 | 1.6 | 1.6 | 4.0 | 7.3 | 0.8 | — | — | — | 26.2 | 50.0 | — | 0.8 | — | 8.2 |
| Diff. | | | 1.2 | 0.3 | 5.6 | 2.5 | 0.1 | — | — | — | 3.5 | 3.9 | — | 0.1 | — | 1.4 |
| E | Upper molar | 234 | 0.7 | 0.7 | 2.9 | 14.1 | 6.7 | — | — | — | 47.0 | 17.9 | — | 1.4 | — | 8.2 |
| $E_1$ | | 255 | 1.9 | 0.6 | 1.2 | 10.3 | 5.1 | — | — | — | 45.1 | 25.1 | — | 1.9 | — | 8.3 |
| Diff. | | | 1.2 | 0.1 | 1.7 | 3.8 | 1.6 | — | — | — | 1.9 | 7.2 | — | 0.5 | — | 0.1 |
| F | Lower molars | 230 | — | 1.6 | 4.0 | 7.2 | 12.9 | — | — | — | 29.0 | 29.0 | — | 1.6 | — | 14.5 |
| $F_1$ | | 241 | — | 1.9 | 2.5 | 5.1 | 11.6 | — | — | — | 32.2 | 34.7 | — | 1.2 | — | 10.3 |
| Diff. | | | — | 0.3 | 1.5 | 2.1 | 1.3 | — | — | — | 3.2 | 5.7 | — | 0.4 | — | 4.2 |
| G | Gingival margin | 227 | 0.7 | 4.7 | 3.9 | 7.0 | 3.1 | — | — | — | 34.6 | 38.5 | — | 1.5 | — | 5.5 |
| $G_1$ | | 238 | — | 2.8 | 5.0 | 5.7 | 2.8 | — | — | — | 41.3 | 35.3 | — | 2.1 | — | 5.0 |
| Diff. | | | 0.7 | 1.9 | 1.1 | 1.3 | 0.3 | — | — | — | 6.7 | 3.2 | — | 0.6 | — | 0.5 |
| H | Upper molar | 412 | 0.1 | 1.2 | 0.9 | 3.3 | 4.8 | — | — | — | 43.2 | 28.4 | — | 8.0 | — | 11.5 |
| $H_1$ | | 200 | 1.0 | 1.0 | 2.0 | 2.5 | 6.0 | — | — | — | 41.0 | 26.5 | — | 6.0 | — | 14.0 |
| Diff. | | | 0.9 | 0.2 | 1.1 | 0.8 | 1.2 | — | — | — | 2.2 | 0.1 | — | 2.0 | — | 2.5 |
| I | Fissure | 247 | — | 3.2 | 2.0 | 2.9 | 0.8 | — | — | — | 46.0 | 36.3 | — | — | 3.2 | 5.2 |
| $I_1$ | | 261 | — | 2.1 | 1.7 | 3.4 | 1.7 | — | — | — | 42.3 | 39.4 | — | — | 5.3 | 4.1 |
| Diff. | | | — | 1.1 | 0.3 | 0.5 | 0.9 | — | — | — | 3.7 | 3.1 | — | — | 2.1 | 1.1 |
| J | Lower molar | 242 | — | — | 4.2 | 5.4 | — | — | 5.4 | 3.7 | 30.5 | 43.9 | — | 1.2 | — | 5.7 |
| $J_1$ | | 292 | — | — | 3.4 | 5.7 | — | — | 4.7 | 3.7 | 25.5 | 48.9 | — | 2.0 | — | 6.1 |
| Diff. | | | — | — | 0.8 | 0.3 | — | — | 0.7 | 0 | 5.0 | 5.0 | — | 0.8 | — | 0.4 |

## TABLE II

*Comparison of the Frequency of Occurrence of Organisms, Determined in Duplicate Estimates of Numbers of Organisms in Smears*

| SERIES | SOURCE | PERCENTAGES OF TOTAL ORGANISMS COUNTED* | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Filaments | | | | Fusiforms | | | Cocci | | Bacilli | | Vibrios | |
| | | Thick | | Thin | | | | | | | | | | |
| | | Plain | Granular | Plain | Granular | Gram-neg. to pos. thin | Gram-neg. short | Gram-neg. to pos. thick | Gram-pos. | Gram-neg. | Gram-pos. | Gram-neg. | Gram-pos. | Gram-neg. |
| K | Molar surface | — | — | 5.2 | — | 11.2 | 21.7 | 6.8 | 32.8 | 8.2 | 5.9 | 8.2 | — | — |
| $K_1$ | | — | — | 6.9 | — | 7.9 | 13.6 | 8.8 | 33.8 | 12.8 | 4.5 | 11.7 | — | — |
| Diff. | | — | — | 1.7 | — | 3.3 | 8.1 | 2.0 | 1.0 | 4.6 | 1.4 | 3.5 | — | — |
| L | Gingival margin | 3.1 | — | 6.1 | — | 5.1 | 0 | 4.1 | 35.0 | 26.5 | 4.5 | 9.1 | 6.5 | — |
| $L_1$ | | 2.7 | 6.3 | 4.9 | — | 3.4 | 1.4 | 5.6 | 32.2 | 22.0 | 6.3 | 7.6 | 7.6 | — |
| Diff. | | 0.4 | 6.3 | 1.2 | — | 1.7 | 1.4 | 1.5 | 1.8 | 4.5 | 1.8 | 1.5 | 1.1 | — |
| M | Gingival margin | — | 10.9 | 5.1 | 2.8 | 16.6 | 1.7 | 9.2 | 36.0 | 15.5 | — | 1.7 | 0.5 | — |
| $M_1$ | | — | 6.6 | 4.4 | 0.8 | 11.9 | 2.2 | 9.4 | 42.3 | 16.3 | — | 5.7 | 0.4 | — |
| Diff. | | — | 4.3 | 0.7 | 2.0 | 4.7 | 0.5 | 0.2 | 6.3 | 0.8 | — | 4.0 | 0.1 | — |
| N | Gingival margin | — | — | 10.9 | — | 4.4 | 5.9 | 9.5 | 37.9 | 21.2 | 1.4 | 8.8 | — | — |
| $N_1$ | | — | — | 8.8 | — | 6.2 | 3.7 | 9.3 | 40.6 | 20.7 | 2.5 | 8.2 | — | — |
| Diff. | | — | — | 2.0 | — | 1.8 | 2.2 | 0.1 | 2.7 | 0.5 | 1.1 | 0.6 | — | — |
| O | Gingival margin | — | — | 6.0 | — | 9.7 | 10.3 | 9.1 | 32.2 | 23.1 | 1.8 | 7.8 | — | — |
| $O_1$ | | — | — | 6.9 | — | 7.1 | 10.6 | 7.1 | 36.8 | 22.5 | 2.1 | 6.9 | — | — |
| Diff | | — | — | 0.9 | — | 2.6 | 0.3 | 2.0 | 4.6 | 0.6 | 0.3 | 0.9 | — | — |
| P | Molar surface | — | — | 3.9 | — | 1.9 | — | 3.4 | 69.1 | 19.1 | 1.9 | 0.7 | — | — |
| $P_1$ | | — | — | 4.7 | — | 1.4 | 6.1 | 2.7 | 64.0 | 14.4 | 2.7 | 4.0 | — | — |
| Diff. | | — | — | 0.8 | — | 0.5 | 6.1 | 0.7 | 5.1 | 4.7 | 0.8 | 3.3 | — | — |
| Q | Gingival margin | — | 2.9 | 1.5 | — | 7.3 | 5.1 | 2.9 | 40.6 | 28.0 | 2.2 | 6.6 | 2.9 | — |
| $Q_1$ | | — | 0.7 | 2.0 | — | 3.3 | 4.8 | 4.8 | 51.7 | 26.8 | 0.6 | 4.1 | 1.2 | — |
| Diff. | | — | 2.2 | 0.5 | — | 4.0 | 0.3 | 1.9 | 11.1 | 1.2 | 1.6 | 2.5 | 1.7 | — |
| R | Gingival margin | — | 5.5 | 4.4 | 2.8 | 0.6 | 1.1 | 5.0 | 35.6 | 30.0 | 3.3 | 7.8 | 3.9 | — |
| $R_1$ | | — | 4.0 | 3.3 | 3.3 | 1.9 | 4.0 | 5.7 | 32.7 | 27.9 | 2.4 | 11.5 | 3.3 | — |
| Diff. | | — | 1.5 | 1.1 | 0.5 | 0.7 | 2.9 | 0.7 | 2.9 | 2.1 | 0.9 | 3.7 | 0.6 | — |
| S | Molar surface | — | — | 2.2 | — | 5.1 | — | — | 72.3 | 19.0 | 0.7 | 0.7 | — | — |
| $S_1$ | | — | — | 3.7 | — | 4.8 | — | — | 62.1 | 20.0 | 5.2 | 4.2 | — | — |
| Diff. | | — | — | 1.5 | — | 0.3 | — | — | 10.2 | 1.0 | 4.5 | 3.5 | — | — |
| T | Molar surface | — | — | 1.3 | — | 9.7 | 7.6 | 2.0 | 54.2 | 21.2 | — | 4.0 | — | — |
| $T_1$ | | — | — | 5.9 | — | 8.8 | 2.9 | 5.1 | 51.9 | 16.0 | 1.4 | 8.0 | — | — |
| Diff. | | — | — | 4.6 | — | 0.9 | 4.7 | 3.1 | 2.3 | 5.2 | 1.4 | 4.0 | — | — |

* Approximately 220 organisms counted in each case.

cedures. In addition, without attempting to draw definite conclusions from material not collected for mathematical analysis, it seems justifiable to suggest that any percentage

TABLE III

*Differences Between Duplicate Counts at Various Percentage Ranges*

| PERCENTAGE RANGE IN AVERAGED DUPLICATE COUNTS | DIFFERENCES BETWEEN DUPLICATE COUNTS | NO. OF DIFFERENCES | TOTAL OF DIFFERENCES | AVERAGE OF DIFFERENCES |
|---|---|---|---|---|
| 0– 2.5 | 0.3; 0.4; 0.7; 0.6; 0.9; 0.2; 1.1; 0.3; 0.9; 0.8; 0.0; 3.2; 0.8; 0.7; 0.0; 0.8; 0.3; 0.1; 0.1; 1.2; 0.1; 1.7; 0.5; 1.4; 0.5; 2.0; 0.1; 1.1; 0.3; 0.5; 0.8; 3.3; 2.2; 0.5; 1.6; 1.7; 0.3; 3.5; 1.4 | 39 | 36.9 | 0.96 |
| 2.6– 5.0 | 1.5; 1.9; 1.1; 0.3; 0.8; 0.9; 0.5; 2.1; 1.1; 0.8; 0.0; 0.8; 0.9; 2.1; 0.6; 0.1; 0.8; 0.8; 0.5; 6.3; 1.5; 1.7; 0.7; 4.0; 2.2; 0.8; 6.1; 0.7; 0.3; 1.9; 1.5; 1.1; 0.5; 2.9; 0.9; 0.6; 1.5; 0.3; 4.5; 4.6; 3.1; 0.4 | 42 | 65.7 | 1.56 |
| 5.1–10.0 | 2.1; 1.3; 0.5; 1.2; 4.0; 0.3; 0.7; 0.4; 0.4; 0.4; 5.6; 2.5; 1.4; 1.6; 0.1; 1.7; 3.3; 2.0; 1.4; 3.5; 1.2; 1.8; 1.5; 1.1; 0.2; 4.3; 2.1; 1.8; 0.2; 0.6; 0.9; 2.6; 2.0; 0.9; 4.0; 2.5; 0.7; 3.7; 0.9; 4.9; 4.0 | 41 | 66.3 | 1.62 |
| 10.1–20.0 | 1.3; 4.2; 2.5; 1.0; 3.8; 4.6; 8.1; 4.7; 0.8; 0.5; 0.3; 4.7; 1.0; 5.2 | 14 | 42.7 | 3.05 |
| 20.1–30.0 | 0.1; 5.0; 3.5; 7.2; 4.5; 0.6; 1.2; 2.1 | 8 | 24.2 | 3.03 |
| 30.1–40.0 | 3.2; 5.7; 6.7; 3.2; 3.1; 3.5; 4.7; 1.0; 2.8; 6.3; 2.7; 4.6; 2.9 | 13 | 50.4 | 3.88 |
| 40.1–50.0 | 2.2; 3.7; 3.0; 6.1; 1.6; 3.9; 1.9; 11.1 | 8 | 33.5 | 4.19 |

TABLE IV

*Magnitude of Errors Expected in Counting Method**

| COUNT | AVERAGE EXPERIMENTAL ERROR | EXPECTED MAGNITUDE OF ERROR | |
|---|---|---|---|
| | | Calculated (Poisson) | Interpolated Standard Deviation (Barnett) |
| 2.5 | 0.96 | ±1.0 | ±1.2 |
| 5.0 | 1.56 | ±1.41 | ±1.5 |
| 10.0 | 1.62 | ±2.0 | ±2.1 |
| 20.0 | 3.05 | ±2.83 | ±2.7 |
| 30.0 | 3.03 | ±3.46 | ±3.2 |
| 40.0 | 3.88 | ±4.0 | ±3.5 |
| 50.0 | 4.19 | ±4.47 | ±3.7 |

* All figures are percentages of total counts.

variations observed by this method which are three times the experimental error are almost certainly real.

## DISCUSSION

The above findings demonstrate that a direct method of smear counting will given an accurate estimate of the percentage distribution of morphologically distinct organisms in the oral flora. The method does not give the specific information provided by cultural observations but, since it is not supposed to be a substitute for cultural procedures but simply a means of directing or supplementing them, this does not detract from its value. Indeed, until some method is worked out to establish the relative importance, in the oral flora, of selectively cultivated organisms, such as lactobacilli or streptococci, claims of their importance as the cause of disease cannot be wholly accepted. It is hoped that the application of this direct smear method to the flora from pathological conditions may point to changes in the percentages of different groups of organisms which will give point to protracted cultural studies of such groups.

## SUMMARY

A method is described for estimating the percentage distribution of various groups of microorganisms in the oral flora. The reliability of the method is indicated by a comparison of the percentages obtained in duplicate counts which show that the experimental error approximates closely the theoretical distribution of organisms.

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# INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH

## Proceedings of the Sixteenth General Meeting[1]
## Hotel Nicollet, Minneapolis, Minn.
## March 12 and 13, 1938

Compiled by EDWARD H. HATTON, *Secretary*[2]

*Northwestern University, Chicago, Illinois*

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[1] The sessions of the Research Association preceded, by agreement, those of the Fifteenth Annual Meeting of the American Association of Dental Schools, in the same hotel, March 14–16. The members of each body were welcome at, and participated in, the sessions of both Associations. The chairmen were the President, Paul C. Kitchin, Ohio State University, and the President-elect, Thomas J. Hill, Western Reserve University. The annual informal dinner, served to members and guests on the evening of March 13 preceding the concluding session, was attended by 109 persons.

[2] William J. Gies, the retiring secretary, has rendered invaluable assistance in the compilation of these proceedings; most of the abstracts have been prepared by those participating. All editorial abbreviations have been submitted to the authors.

## I. Address of Retiring President*

*Paul C. Kitchin, M.S., D.D.S., F.A.C.D., Dental School, Ohio State University, Columbus, Ohio*

We are saddened by the loss during the past year of two past Presidents of this Association. Dr. Theodore Beust died on November 24 and Dr. Arthur Black on December 7, 1937. Their lives and accomplishments are indelibly linked with the International Association for Dental Research, a fact of which this group is justly proud. To Dr. Black and Dr. Beust, Dentistry will be forever in debt. With mingled sorrow and pride we force ourselves to realize that they have laid down the torch and become a part of our professional heritage.

For eighteen years this Association has been nurtured and guided through the difficulties of infancy and adolescence. Like a kind and wise parent and disguised as a General Secretary, one man has constantly pointed out the best path, made good our deficiencies and kept us going. From an annual meeting in 1920 with an attendance of 26 and a program of 2 papers, representing 3 Sections, this Association has developed to this year's gathering of 170 and a program of almost 100 presentations from 27 Sections, scattered over 4 continents. The obligations and responsibilities of maturity are now ours and Dr. Gies very properly wishes us to assume them. His retirement from the position of General Secretary at the close of this meeting is in the interests of this maturation process. We will never outgrow the need for his help but we must ease his burden by learning to meet and successfully handle our own problems. To Dr. Gies we owe our start, our progress and a future development which will make him proud of what he started.

For our incoming Secretary, Dr. Hatton, we would urge on each and every member, and especially Section officers, the assumption of an individual and personal responsibility in those things which will aid him and by so doing avoid making his work any heavier than it must necessarily be for the proper functioning of this Association.

Two years ago Dr. Gies began a transfer of the *Journal of Dental Research* to the International Association for Dental Research. The

*This and the two succeeding addresses were delivered after the annual dinner at the sixth session (March 13), before the concluding executive proceedings (page 339).

*Journal*, initiated by Dr. Gies in 1919, is now the official publication and the responsibility of this Association. To the Publication Committee of the *Journal* this Association owes its most sincere appreciation for their splendid work of the past year. A formal expression of that appreciation however is not the only sincere way. The most sincere and practical way is the unsolicited subscription to the *Journal* by every member of this Association, and a sustaining subscription wherever such is possible.

To Dr. H. G. Worman, secretary of the Minnesota Section, and the other members of the Section who have constituted the local Committee on arrangements, this Association desires to express its approval and thanks for their successful efforts to handle all the numerous and elusive details which fall to the lot of such a committee. I believe that I speak for every member of the International Association for Dental Research, present at this meeting, when I say that we gratefully acknowledge the hospitality and kindness shown us. We will long remember our visit to the great state of Minnesota, farthest west-flung part of the Northwest Territory, a state which is the mother of ten thousand lakes and whose rivers pour their waters into three oceans; and to the city of Minneapolis, home of a great University, a renowned orchestra and picturesque mills supplying flour to a nation.

## BEYOND THE MICROSCOPE

The relativity of truth to time and place, and we might add "ability to see," is generally accepted. Thus our conceptions of "why" and "how" approach more closely to the ultimate truth with improvement in methods and means of observation, hindered only by our degree of ability to interpret correctly that which can be seen. When Emerson wrote in 1837, "It is a mischievous notion that we are come late into nature; that the world was finished a long time ago," he stated a fact that is as applicable today as it was one hundred and one years ago.

From the crude rifle-sight type of apparatus of Copernicus through the telescope of Galileo, down to the ultra-modern observatory telescope of today, man has continually and profitably sought to increase his knowledge of the universe by improving and adapting to his needs

the optical aids at his disposal. While some turned their eyes toward the heavens, others sought to bring into the range of vision the minute structures of their surroundings, in this never ending attempt to find the answers to the eternally irritating "why" and "how." The linen draper and lens grinder of Delft, van Leeuwenhoek, with his simple bi-convex lens and concave mirror, did much to open up this world of the microscope, contributing 112 papers to the Royal Society of Great Britain. While history records that either Hans Jansz or his son Zacharias had probably made a compound microscope 40 years before van Leeuwenhoek was born, the latter's instrument was so much more powerful and put to so much better use in the search for "why" and "how" that he may well be called the "father of the microscope."

It is rather strange to find that, despite the abundance of mathematical and optical knowledge of the early centuries of the Christian era, it was not until the sixteenth century that microscopes began to receive the serious attention of the mathematicians and physicists. Steadily from that time forward, however, this key to the world of the minute has been improved, both mechanically and optically.

In dentistry, as in all other fields of biological and physical endeavor, the microscope has performed, and will continue to perform, a major service in the establishment of a factual physical and biological foundation upon which to base rational clinical procedures and from which to direct further investigation.

Unfortunately there are rather set limits to the power of the biological microscope in ferretting out the ultimate structure of tissues. This is especially true in the case of bone and the hard dental tissues. By the very fact that they are products of 2 quite distinct processes, the formation of a matrix and the subsequent calcification of the same, they thereby fortify themselves against the efforts of the histologist who is equipped only with a magnifying apparatus. Perhaps the most resistant of these hard tissues is the tooth enamel.

The resolving power of the microscope is limited by the wave length of the light used and the numerical aperture of the objective. As the details of an object in the field of vision become so minute that the enlarged images of them touch or overlap, definition is lost. Under ordinary conditions of observation, objects under 0.2 micron are invisible, though with unusually high apertures, as in the case of

monobromnapthalene immersion, or using ultra-violet light and photography, objects down to 0.1 micron can be distinguished. Under favorable conditions, largely a matter of enough separation between minute structures, we may even get down to 0.004 micron with the darkfield apparatus. Strictly speaking therefore, the so-called "structureless parts" of tissues are in all probability only those in which no structure has yet been demonstrated. With cellulose fibers at least, this seems to be true. Their make up from the atoms to the microscopically visible fibers has been traced by various means. In muscle and collagenous fibers we have situations where it is indicated that the long dimensions of the individual microscopic units are microscopically identifiable while the shorter dimensions are submicroscopic, meaning that these shorter dimensions are below the limits of resolution.

Thus the microscope carries on very well to the limits of its resolving power. Taking off, so to speak, from the frontiers of contemporary magnification possibilities we must turn, as have the astronomers, to the observation and interpretation of light signals.

The examination of tissues by means of the roentgen-ray is one of these indirect methods which, in conjunction with chemical analyses of known substances, has brought about the identification of many unknowns. By this means the crystalline or amorphous character of the material is revealed and where the crystalline characteristics are present it is possible to distinguish the single crystals or aggregates of them and also to determine crystal dimensions and orientation. The roentgenogram method applied to bone, enamel and dentin has established the isomorphism of the crystal units of the inorganic component with the mineral apatite, hence placing them in the uniaxial hexagonal crystal group. However applying the roentgenogram procedure to minute areas of tissue is very uncertain and this type of examination involves expensive equipment and a technique not often included in the training of the biologist interested in dental investigation; while the physicist in whose province such technique is more common, usually lacks a knowledge of tissue structure. This gap is being bridged.

Another indirect method and one involving less expensive equipment and less intricate technique is afforded by the study and inter-

pretation of birefringence phenomena of tissues as revealed by polarized light. This method, contrary to general opinion, is not a recent development. It is much older than the use of the roentgen ray. The first polarizing prism was made by a Scotchman, William Nicol (1), in 1828. He used a combination of 2 specially ground and polished crystals of Iceland spar (calcite), cemented together with Canada balsam to form what is now termed the nicol prism. Calcite is a birefringent material and the angle at which the 2 polished surfaces are cemented to each other, together with the angle of the end surfaces, are so arranged that of a ray of light entering at one end and dividing into 2 rays, an ordinary and an extraordinary, the ordinary ray strikes the Canada balsam at an angle exceeding the critical angle and as a consequence is totally reflected and eliminated. The extraordinary ray passes through the balsam and emerges from the prism polarized, that is vibrating in a single known plane.

In the polarizing microscope one of these nicol prisms, the polarizer, is located below the object stage and receives light from the source of illumination. A second nicol, the analyser, is placed in the microscope tube below the ocular with its Canada balsam layer at right angles to that of the polarizing nicol.

We have attempted to explain the effect of the lower nicol in polarizing light entering the optical system. If now there is placed on the object stage a thin section of material, for example tooth enamel cut along the long axes of the individual birefringent rods we find that the ray of polarized light coming from the lower nicol is further resolved into an ordinary and an extraordinary ray by the enamel. That is, light passes through enamel with different velocities and vibrating in planes at right angles to each other. These two rays travel at different velocities because one finds it more difficult to get through the enamel than does the other. On account of the difference in velocities of the 2 rays in passing through the enamel, one of these rays (ordinary ray) is slowed down and a path difference (retardation) is established.

When these 2 rays from the enamel reach the upper nicol each of them is resolved into 2 components, vibrating at right angles to each other. In each of the 2 planes we find a component of each of the 2 rays coming from the enamel. The pair vibrating in one plane are

totally reflected, as in the lower nicol, but in the case of the other pair they pass through the upper nicol vibrating in parallel planes and because of the retardation of the ordinary ray in the enamel, optical interference due to phase difference takes place. This interference due to phase difference of the ordinary and extraordinary rays from the enamel causes interference colors when these rays are reduced to the same vibration plane in passing through the upper nicol. When monochromatic light is used a phase difference in the 2 rays of a half wave length, or an odd number of half wave lengths, produces darkness. When white light is used a half wave length retardation cannot exist for all the different wave lengths in white light, so that in this case, instead of darkness, colored light is produced.

This interference color depends on 3 factors, namely (1) the birefringence of the material, which is the difference in the indices of refraction of the 2 rays; (2) the direction of light transmission through the material; and (3) the thickness of the section.*

It would take much more time than has been allotted and more patience than this audience should reasonably be asked to expend, even on a Presidential address, to go further into detail on the technique of the polarizing microscope. Suffice it to say that it is quite possible to determine through a study of the birefringence in any doubly refracting material, the shape of the submicroscopic unit of structure, its 2 different indices of refraction and their relation to the several axes of the submicroscopic unit, and the relation of the submicroscopic unit to the microscopically visible units. The possibilities of seeing beyond the microscope in this piece of enamel on the object stage, due to the manner in which it influences the polarized light passing through it, are very real.

I should like now to show what use has been made of this birefringent property of the hard dental tissues in the study of their structure which lies beyond the resolving power of the usual microscope. A considerable period of time elapsed between the invention of Nicol's polarizing prism and the first recorded observation and inter-

* I wish to express my sincere appreciation to Dr. William J. McCaughey of the Department of Mineralogy, Ohio State University, for his help in formulating this description of the birefringence phenomena in particular, as well as for his kindly interest in our dental problems and his many helpful suggestions.

pretation of birefringence in tooth tissue. In 1861 G. Valentin (2) published an article in which he described the negative birefringence of enamel. The next year Hoppe (3) examined enamel, dentin and cementum and stated that they were birefringent, enamel most of all. Hoppe attributed their optical properties to the crystal arrangement of the salts. He also noted that enamel could be either positively or negatively birefringent and that heat caused an originally negative condition to revert to positive.

For almost the next 30 years the literature is apparently devoid of reference to further use of the polarizing microscope for the study of dental tissues. It was not until 1890 that von Ebner became interested and his contributions on this subject including bone (4, 5, 6, 7, 8, 9) covered the period from the above date until 1906. Von Ebner noted a peculiar phenomenon regarding enamel which appeared to be optically positive when immersed in water or alcohol. If the same section was freed of the above immersion media and placed in oil of clóves the positive areas then became negative and on removal of this liquid and reimmersion in water or alcohol positive birefringence was reëstablished. Von Ebner concluded from this that there was no permanent change in the structure of the enamel, since the original optical condition returned. He reasoned that the immersion liquid could penetrate into this optically positive enamel area and in doing so varied the tension between the particles composing it and hence the change in sign of birefringence. This, according to him was the cause of reversal of optical properties. He considered that he had proved that the enamel rods increased both in size and density of calcium salts with age. Generally speaking then, we may say that von Ebner considered the change in optical properties which positive enamel could undergo to be one of variation in strain, or tension among the enamel particles, and he believed young enamel to be optically positive in its birefringence and to become negative with age. Von Ebner's "tension" theory of birefringence in tissues has been generally discarded because when applied to certain birefringence phenomena it leads to absurd conclusions. However, as far as the young positive enamel is concerned his observation of penetrability has been generally confirmed.

In 1903 E. C. Kirk (10) devoted part of an article to discussion of

the observation of ground tooth sections in polarized light. Kirk confused transparency and birefringence and believed that the mineral salts alone were responsible for the birefringence phenomenon. Kirk was apparently unaware of the work done by Valentin, Hoppe and Von Ebner, if we judge by his absence of bibliography. He was quite correct in his belief that what he termed "greater transparency," meaning increased birefringence, could (under certain conditions of observation) indicate greater concentration of calcium salts. However, had he examined end sections of enamel rods, his idea would have had a severe shock, since the birefringence of enamel is only apparent when looking down on the side view of the rod. In end view there is no birefringence, but this is no proof of lack of calcium salts.

From 1906 to 1921 I have been able to find no reference in the literature which would indicate the further use of the polarizing microscope in the study of the dental tissues.

In 1921 V. Andresen (11) published the results of a study of artificial and physiological remineralization of enamel in which he used the change in sign of birefringence of enamel, which had supposedly become optically positive due to caries and then later, as a result of remineralization, again negative, as a proof of his claims.

We now come to the work of a man who in my opinion has brought to bear upon this problem the best combination of knowledge of tissue structure and ability to recognize and interpret birefringence phenomena. In 1923 W. J. Schmidt published his first work (12) on the structure of tooth enamel. This has been supplemented by a number of more recent contributions (13, 14, 15, 16, 17, 18, 19, 20, 21) covering in addition to tooth tissues, bone and many other animal, as well as plant, tissues. Schmidt's work is based on an extensive knowledge of the optical principles involved as well as considerable familiarity with the histological structures with which he has worked. His studies have been conducted with a due consideration of all the work previously reported in this field. Having placed him chronologically I should like to return later to a more detailed consideration of his findings in the dental field.

Cape and Kitchin (22) presented the results of their observations by polarized light and roentgen ray analyses of dentin and enamel in 1929. While they were aware, from statements made in Mum-

mery's text (23) on dental histology, that some observations had evidently been made on dental tissues in polarized light by von Ebner and Fischer, they were unable to consult these in the original and there were no publications in English on this subject, excepting that of Kirk. As a consequence their study was carried out without any knowledge of previous observations other than the brief references of Mummery. In the light of the observations of Schmidt their work is open to criticism, especially in that they failed to consider their results in the light of Nägeli's micellar theory and from the standpoint of the phenomenon of form birefringence in mixed bodies as it had been demonstrated by Ambronn. Their interpretation of optically positive, isotropic and negative forms of enamel and their explanation of the change from one to the other must be reconsidered in the light of Schmidt's work. A similar criticism can be applied to the theories advanced by Kitchin (24) on the interpretation of the optical changes which he saw in the development of the enamel in the rat incisor. On the whole, however, and if we except theories advanced, the things reported by Cape and Kitchin agree quite well with previous work and their publication did contain some subsequently verified and hitherto unreported phenomena. Of the latter, the semi-lunar areas of calcification in the dentin and the production of changes in birefringence of enamel through decalcification might be mentioned. Their figures on the index of refraction and birefringence of enamel have been proven to be quite reliable.

Applebaum (25) reported a study of incipient enamel caries by polarized light in 1932. In it he classified the submicroscopic unit of calcification in the enamel as a "biaxial" crystal, which is an error, all other observers agreeing on it's being a uniaxial crystal form and therefore falling in either the hexagonal or tetragonal system. X-ray determinations by Funaoka (26), Cape and Kitchin (22), Möller and Trömel (27) and others all indicate the isomorphy of the inorganic enamel crystal unit with apatite, and therefore a uniaxial form. Applebaum's description of an area of enamel containing both carious and non-carious parts, presumably a tooth which had been remineralized, in which he stated that the band of demarkation between the two is optically positive, certainly does not seem to agree with the accompanying illustration which shows the band to be isotropic

(black). The only reference that Applebaum makes here to previous work with polarized light on dental tissues is to that of Andresen (11).

Applebaum published in 1935 an article (39) in which he included several references to polarized light phenomena of dental tissues in an optical study of active and arrested incipient caries lesion.

The work of Proell and Diener (28) contained several historical and factual errors which were pointed out by Schmidt. They stated that there were (1933) no publications on the orientation of the crystal forms in enamel and dentin when both Schmidt and Cape and Kitchin had published on this matter, and they attributed to Gross (29) the first exposition of a polarizing procedure for studying the hard tooth tissues in disregard of the previous work of Schmidt (19). They also erroneously described the orientation of the mineral crystals in dentin as perpendicular to the tooth surface, whereas Schmidt had already shown them to be arranged with their long axes parallel to the course of the collagenous fibers and hence tangential to the tooth surface and analogous to the relation found in bone. Proell and Diener reverted to the stress theory of von Ebner in attempting to relate the stresses of growth to crystal orientation.

Two of Schmidt's pupils have made contributions to the dental literature on the basis of observations with the polarizing microscope. Albert Keil has published 5 articles (30, 31, 32, 33, 34) in the period from 1934 to 1937, and Gertrude Erler has published one (35). As would be expected these workers base their deductions on their teacher's theories and follow his technique. The combined publications of Schmidt, Keil and Erler present a quite formidable array of data on the structure and changes in the hard tooth tissues as observed in polarized light.

Since Schmidt is by far the outstanding contributor in this particular field I should like to review as briefly as possible the substance of his results and theories along with some of Keil's, regarding especially the enamel and dentin. As will be seen when consulting the bibliography following this presentation, 5 of Schmidt's publications deal generally with plant and animal tissues, 4 of them are concerned solely with tooth tissues while one is confined to bone. It is thus apparent that we have here someone who is equipped with a broad biological interest and well grounded in interpreting the optical phe-

nomena presented in tissue material when it is studied with the polarizing microscope. Schmidt's publication (12) on the analysis of the submicroscopic structure of cells and tissues by means of polarization optics is in reality a manual on this technique and the only one that I am aware of with the exception of that written by Ambronn (36) many years ago. In this manual of Schmidt's there are discussed the fundamentals of the optics concerned; methods of proceedure; birefringence, both of the individual units of structure involved and that type of birefringence encountered in mixed bodies which has been designated as form birefringence and is due to the arrangement of the submicroscopic units; and also the use of the various accessories of the polarizing equipment. The latter half of the manual deals with the technique as applied to specific plant and animal tissues including the tooth enamel, bone, nerve fiber, hair, etc. The purpose of this comment on Schmidt's work is to again emphasize the wealth of experience which he brings to bear on this type of tissue investigation where the object is to probe beyond the resolving power of the biological microscope. In the specific field of dental investigation he has done much to clear a confused situation and provide a logical conception of the submicroscopical structure of enamel, dentin and bone.

During the remainder of this discourse I should like to talk about some of the things which, I believe to have been reasonably demonstrated, and which "lie beyond the microscope."

The inorganic part of the microscopically demonstrable enamel rod is made up of submicroscopic crystals which are hexagonal in shape and have their long axes lying along the long axis of the rod. There may be a deviation of as much as 20 degrees in this relationship in human enamel while in dog enamel the parallel arrangement is the general rule. These units are optically negative which means that the index of refraction of light, vibrating at right angles to the long axis is greater than that of the light vibrating in the plane of the long axis. In other words, since the higher index indicates a greater difficulty in light movement, light moves more easily when it vibrates in the plane of the long crystal axis than when it vibrates at right angles to this plane. This much is agreed upon by all workers who have analysed the birefringence of mature enamel, but in addition to this condition practically all workers have seen enamel which is isotropic,

meaning that it has no birefringence, and enamel which has a positive birefringence. There is a general agreement that forming enamel has a positive birefringence and that between these positive and negative areas there is invariably isotropic enamel. The question and source of difference then is; what is the relationship between these differences in birefringence? Both von Ebner's explanation of variation in internal stress and Cape and Kitchin's explanation on the basis of possible difference in chemical composition, hence solid solution phenomena and a shifting of values for ordinary and extraordinary rays, are difficult to reconcile with what would have to occur in the crystal units to produce these optical differences. It is here that Schmidt's explanation seems to be the reasonable one. It is based on the generally accepted Nägeli (38) particle theory of tissue structure birefringence. Briefly this postulates that such birefringence is due to the crystalline nature of regularly arranged, anisodiametric, submicroscopic particles separated from each other by very minute spaces. In connection with this theory Schmidt also includes the differentiation between the birefringence which is actually due to the proper particles of a tissue and a form of birefringence which arises as a result of the particle-space condition. This last is dependent on the index of refraction of air or any liquid which may be introduced into the spaces. In a series of experiments on optically positive young elephant enamel and on optically positive areas in otherwise mature human enamel, Schmidt observed identical thin sections in polarized light in immersion media of widely varying index of refraction. He found that when the index of the immersion medium was very close to, or the same as, that of mature enamel (1.62) that the areas which had been optically positive in media of lower index (air and water), were now negative. This change held up to an index of about 1.7, but with methylene iodide, at 1.74, the material again became positive, though more weakly so than in air and water.

A reversal of this series of birefringence changes was obtained by starting with enamel, which showed a positive birefringence in air dry condition, placing it first in pure methylene iodide (1.74) and adding gradually more and more xylol (1.49). Here the area of enamel was at first weakly positive in the methylene iodide, then isotropic, next increasingly negative up to a maximum negative birefringence

with the immersion medium index paralleling that of enamel (about 1.62), then dropping to an isotropic condition and finally, when pure xylol was the immersion medium, the enamel was definitely positive. This double reversal of sign of birefringence is acceptable proof that form birefringence is involved. Form birefringence can be eliminated by placing the material in an immersion medium with an index equal to that of the material particles. Thus it has been shown that the birefringence of the enamel particles themselves, when form birefringence is eliminated in the case of apparently positive or isotropic enamel, is of a negative sign. Mature enamel shows no such dependence on the index of refraction of the immersion medium, it is optically negative under all conditions.

On the basis of these experiments, the particle theory of tissues and the elimination of confusing form birefringence which masks the real particle birefringence, Schmidt pictures the inorganic part of forming enamel with the microscopically visible rods being composed of submicroscopic hexagonal crystals whose long axes lie in planes approximately parallel to the long axis of the rod. These crystals have a negative birefringence and are separated by spaces quite similar in shape to those of the particles, which spaces will later be filled with more crystals as the enamel matures until the rod is a solid mass of crystals in the mature condition. In this state it is impenetrable to immersion liquids.

From this point of view the optically positive and isotropic enamel areas are so because of the material which lies in the submicroscopic, uniformly oriented spaces between the crystals of inorganic material. Where positive birefringence is apparent, the form birefringence (positive in enamel) has overcome the negative birefringence of the crystals. Where isotropy occurs, the form and actual birefringence of the crystals exactly balance each other, just as it should happen with a constant growth of crystals taking the place of the spaces.

Having interpreted the light signals from the enamel let us now do the same for the dentin. The fundamental observation that dentin birefringence was due to the presence of calcium salt impregnated fibers was made by von Ebner in 1875. By observing the optical properties he stated the course of these fibers to be approximately at right angles to the dentinal canals. In 1891 J. Schaffer removed the

inorganic matter from dentin sections and noted that the birefringence of the remaining inorganic part changed with change in index of the imbibition media used, as with bone. Schmidt has shown that the inorganic part of dentin is made up of crystallites with the same optical properties as those found in enamel and are arranged with their long axes parallel to the long axis of the collagenous fibers. In addition to this arrangement, Cape and Kitchin (22) pointed out the semi-lunar areas seen in polarized light in the dentin, as a calcification phenomenon. Later A. Keil corroborated this and further showed that they are due to an initial phase of calcification in spherite form with the long axes of the crystals arranged radially. Farther along in the dentin spherical calcification gradually gives way to the general arrangement of crystals in relation to the collagenous fibers. This semi-lunar phase of calcification in dentin confirms Czermak's (37) contention of spherite calcification and differs from anything evidenced in bone where according to Schmidt's observations, the inorganic, submicroscopic crystals, similar in optical properties to those shown in enamel and dentin, are all arranged with their long axes parallel to the course of the collagenous fibers.

Birefringence studies of dentin, and bone as well, are complicated by the fact that both the inorganic and organic crystalline units are birefringent and the total birefringence is a combination of the two. These birefringences can be opposite in sign. To get around this difficulty it has been necessary to work with sections freed of organic matter and sections freed of inorganic material. Schmidt, working in this fashion, has shown that the collagenous fibers are made up of submicroscopic units with positive uniaxial birefringence and with their long axes parallel to the fiber length. The arrangement and form of the inorganic units have been previously described. They have a negative birefringence, hence this conflicts with that of the fiber units. This then is the picture of the submicroscopic condition in dentin as interpreted from its birefringence.

Several workers have reported the observation that heat, artificial decalcification and caries will change negatively birefringent, hence mature, enamel back to a positive condition. It has already been stated that this is the usual type of birefringence in forming enamel. Keil has shown that of these 4 conditions of positive enamel, only 2,

the young and the artificially decalcified will show the double reversal of the sign of birefringence with changing index of immersion media. Enamel which is optically positive due to the action of heat and caries remains of that sign of birefringence independent of the index of immersion medium. In giving serious consideration to the submicroscopic structure picture of enamel which Schmidt has presented, it becomes apparent that something must have happened to the structure of the enamel in caries and in heating to set it off from the condition obtaining with artificial decalcification and normally immature structure. At present the only explanation offered is that the spaces arise (in consistency with the explanation of positive enamel) but for some reason they are not accessible to the immersion media in which the section is placed. Keil has reported a further study of these forms of positive enamel on the basis of difference in form birefringence and actual particle birefringence. He has shown that the largest amount of submicroscopic spaces are present in the caries positive enamel, showing there almost twice that of artificially decalcified enamel and more than twice that of enamel made positive by heat. If these results of Keil's are confirmed from other sources, this difference in behavior between artificially decalcified enamel and that which is undergoing a carious decalcification is additional evidence against interpreting caries of the enamel as purely a decalcification phenomenon. It also would make it difficult to explain the remineralization for the amelioration of caries, claimed by Andresen, as due to physical processes.

We have wandered around considerably in this field beyond the microscope, groping our way about in the interior of enamel rods in various stages of development and decomposition and in the dentin ground substance, far removed from the relatively open highway of the tubules. If I have tired you and taxed your patience unduly, I apologize. Nine years ago, based only on my own observations, I made the statement that the technique of the polarizing microscope was the logical way of approach to the study of tooth tissues and when properly applied and correctly interpreted would increase our knowledge of dental histology and tissue changes. I believe that the data collected by various workers and here presented proves that it has done so. Texts on general histology discuss the birefringent qualities

of muscle and bone as indicating structural features; would it be premature to suggest that from a dental standpoint we have quite enough data to give due consideration to the optical properties of dental tissues and what these properties seem to indicate regarding ultimate units of structure? The fairly long list of bibliographical references, most of them on the birefringence of tissues, which furnish the material basis of this presentation and are appended to it, indicate that this field beyond the microscope is not entirely a land of make-believe. Rather it deserves our serious consideration, both for what it has already furnished and its possibilities for future harvest.

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## II. INTRODUCTION OF THE PRESIDENT-ELECT

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In a situation such as this we are reminded of the adage, "The King is Dead, Long Live the King." We have just enjoyed a meeting which has been the culmination of the very arduous efforts of our retiring president, Dr. Kitchin, and his very able staff. We are now looking forward to the meeting next year which will be directed by our newly elected president.

In the preparation of this introduction I tried to think of some nice things that I might say about our new president. In doing so, I was reminded of the fact that he is a good teacher, that he possesses that remarkable ability of enthusing his students in the subject which he teaches. Next I was reminded of his scholastic and scientific attainments. For many years he has been a keen student of his subject and has contributed very largely to the sum and total of our knowledge of many problems in dental pathology. In his association with Dr. Karsner he has made many notable contributions to the literature of his field. But lastly, and perhaps what is more important, I thought of him as a friend, a man who has the ability to create warm personal friendships, and one toward whom all those who know him

feel that he is first of all a man, a man whom they would delight in knowing. And so, with these qualifications in mind, I take great pleasure in introducing to you the new president of this organization, assuring you of my full confidence, in which I know you share, that the splendid work of the preceding year will be carried on and will be successfully administered by the teacher, the scientist, and the friend, Dr. Thomas J. Hill.

## III. Inaugural Address

*Thomas J. Hill, D. D. S., F. A. C. D., Dental School, Western Reserve University, Cleveland, Ohio*

In accepting the presidency of The International Association for Dental Research, I am not unmindful of the honor which it carries. I am however more fully conscious of its duties, its obligations and its opportunities.

Not long ago the small amount of dental research that was conducted was the result of scattered, individual effort and received comparatively little university support. To stimulate more active research, to promote a cooperative spirit among workers and to provide an opportunity for the interchange of ideas, this organization was founded. The Association has gone a long way toward the realization of these aims. It has grown into an organization, which, in addition to the one in the United States, has Divisions in Austria, Canada, China, Czechoslovakia, England, Hungary and South Africa, with unattached members in Germany, Holland, Hawaii, Italy, Scotland, Switzerland and Uruguay. Hence, its influence today is truly international. It is the medium through which nearly one thousand papers of original research have been given to the profession. Through its organ, *The Journal of Dental Research*, it provides an effective means for the dissemination of this information. The International Association for Dental Research is a material influence in the promotion of university interest in dental research and in the encouragement of men interested in dentistry as a science.

The American Division of this organization sponsors, with the aid of the American Dental Association, the American Association of Dental Schools and The American College of Dentists, the subsection

on dentistry of The American Association for the Advancement of Science.

That these accomplishments could be achieved in so short an existence is the result of a foundation firmly laid by its founder, Dr. Gies, and a framework honestly and ably constructed by the preceding officers. With a knowledge of these past attainments, an understanding of its aims and purposes and a vision of its increasing usefulness, I promise my efforts to "carry on."

## IV. Index of Names of Participants, and Sequence Numerals of Corresponding Abstracts

Adam, 77; Aisenberg, 31; *Allen, 75; Applebaum, 76, 77; Armstrong, 1, 21; Bale, 47; *Balkin, 10; *Becks, 78, 79, 80; Bessey, 82; Bevelander, 44; Bibby, 38; Blayney, 12; Bleiker, 81; Bodecker, 40, 41; Boling, 43; Boyle, 82; Brawley, 2; Brekhus, 1, 21; Brening, 51; *Brodsky, 83; *Bucky, 83; Bunting, 60; Burket, 22, *84; Cahn, 40; Campaigne, 25; *Chase, 85; Cheyne, 19, *75; Claflin, 29; Cohen, 17; *Cook, 86; Csernyei, 62, 63; Cummings, 94; Cushman, 14; Damon, 55; Deakins, 4; Denton, 13; Diehl, 57; *Downs, 87; Drain, 19; Driak, 65; Dubé, 89; Dunning, 88; Etherington, 14, 15; Fenske, 11; Figi, 90; Ford, 54; Fosdick, 23, 24, 25; Gies, 52; *Gillam, 105; Gottlieb, 66; *Grohs, 67; Haber, 50; Hammond, 9; Hampp, 28; Hansen, 8; Hill, 61; Hodge, 48; Hofer, 68; Hoffman, 37; Hollander, 88; *Holstein, 101; Hoskins, 44; Jonge-Cohen, 64; Jump, 46; Kanner, 32; Karshan, 91, 104; Kellner, 69; Kitchin, 20, 59; Klein, 26, 95; Kornfeld, 92; Kotanyi, 70; Kramer, 95; Krasnow, 93; Kronfeld, 30; Lasby, 56; Lasater, 35; LeFevre, 47; Lefkowitz, 41; Losch, 15, 94; Luckhardt, 5, 6; Manley, 27; Margolis, 16; *McKeown, 87; Midgley, 58; Morse, 45, 94; Myers, 34; Oblatt, 93; Palmer, 26, 95; Pfeiffer, 34; Pickering; 5, 6; Pichler, 71; Price, 96, 97; Rittershofer, 98; Robinson, 43; Rudolph, 53; *Schönbauer, 72; Schour, 37; Sedwick, 2; Simon, 1; Skinner, 33, 89, 99, 100, 107; *Smith, 105; Snyder, 102; Stafne, 90; Stein, 73; Steinmyer, 5; Sulser, 51; *Swanson, 101; Tainter, 7; *Taylor, 103; Tenenbaum, 104; Thayer, 45; *Thoma, 106; G. E. Thompson, 36; J. R. Thompson, 49; Throndson, 7; Trimble, 15; Tunnicliff, 9; Turbyfill, 107; *Van Kirk, 101; Visscher, 3; Volker, 108; *Wainwright, 78, 109; *Waldron, 18; *Waugh, 42, 110; Weaver, 20; Weinmann, 74; Weisberger, 39; Wessinger, 24; *Worman, 111; Wright, 11; Yates, 45; *Zemsky, 112.

## V. First Session: Morning, March 12; Abstracts 1–10

1. Stimulation of muscles of mastication. *P. J. Brekhus, B.A., D.D.S., F.A.C.D., W. D. Armstrong, Ph.D., M.D., and W. J. Simon, B.A., D.D.S., School of Dentistry, University of Minnesota, Minneapolis, Minn.* Bite strengths of control and experimental subjects were recorded by hydrostatic gnathodynamometer. Ex-

* No manuscript received for publication.

perimental subjects were required to chew ½ inch cube of paraffin for 1 hour each day for 50 consecutive days. Average increase in bite strength after this stimulation was 23.60 pounds. Two weeks after completion of stimulation a "follow-up" bite was recorded. Average bite strength of experimental group at close of 2 week rest period decreased to within 0.41 pounds of original bite strength. This gives convincing evidence that 23.60 pounds increase in bite of this group is due to exercise of muscles of mastication, not to practice on the instrument. In control subjects if the highest registered bite is regarded as the variate, it is not possible to increase bite significantly by practice on gnathodynamometer. With increasing prevalence of caries, malocclusion, and gingival disease there is a decrease in tone and strength of muscles of mastication which can be increased by exercise.

2. STUDIES CONCERNING ORAL CAVITY AND SALIVA. IV. CALCIUM (1) CONTENT OF CHILDREN'S SALIVA. *Robert E. Brawley, B.S., D.D.S., M.S., and H. Jobe Sedwick, D.D.S., Department of Pediatrics, School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* Calcium determinations made on resting and activitated saliva of 780 children, 3–18 years of age. The data show: (1) No significant differences with age or sex, (2) significant variations with season and type. Average calcium values in mgs. per 100 cc., resting saliva 6.89, activated 6.24.

3. COMPARATIVE STUDY OF SALIVARY AND OTHER SECRETIONS. *Maurice B. Visscher, Ph.D., M.D., Department of Physiology, University of Minnesota, Minneapolis, Minn.* pH of stimulated submaxillary gland saliva of 15 anesthetized dogs varied between 7.25 and 8.58. Dye secretion studies, using 8 acid dyes and 7 basic dyes, of submaxillary saliva, urine, and aqueous humor indicated that there is no selectivity in elimination of dyes by organs tested; this is in contrast to the situation in the pure acid and base secreting glands (stomach and pancreas), since it was found that only electropositive dyes appeared in gastric, and only electro-negative in the pancreatic secretions. Only kidney showed regularity in secreting every dye used. Aqueous humor contained all acid and 1 out of 5 basic dyes. Saliva contained 3 of 8 acid and only 1 of 7 basic dyes. These organs

resemble pancreas more closely than gastric mucosa, but there is no exact similarity. Dye secretion studies support view that salivary gland is not a typical alkali secreting gland.

4. CATALASE IN SALIVA. *Martin Deakins, D.D.S., M.A., School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* Catalase, the enzyme found in nearly all cells which decomposes hydrogen peroxide was shown to be present in whole saliva. It is inactivated by heat. Centrifuging divides it about equally between liquid and centrifugate, while a Berkfeld filtrate (first 10 cc.) contains only about $\frac{1}{3}$ of enzyme. Stimulation of salivary flow by paraffin chewing does not increase catalase content proportionately. Saliva kept fresh for 6 weeks shows greater activity than fresh saliva. Concentration of enzyme varies among individuals; it also varies with time in same individual.

5. HEMODYNAMIC EFFECTS OF PROCAIN-EPINEPHRINE HYDROCHLORIDE ANESTHETIC SOLUTIONS. *Herbert P. Steinmeyer, D.D.S., B.S., Paul P. Pickering, D.D.S., B.S., and Arno B. Luckhardt, M.D., Ph.D., F.A.C.D., Walter G. Zoller Memorial Dental Clinic and the Department of Physiology, University of Chicago, Chicago, Ill.* Fifty-seven dogs anesthetized with paraldehyde, set up to record carotid blood pressure, were used. (a) Epinephrine doses of 0.28 cc., 1:1000 concentration, per kg. body weight, were injected into subcutaneous, submucous, and mandibular foramen areas. Blood pressure rises following injections indicated greatest absorption from mandibular and least from subcutaneous injections. Massaging injected areas elicited blood pressure rises, but not as high as those following injections. (b) 2 per cent procaine-epinephrine solutions, epinephrine concentrations 1:10,000–1:50,000, injected in 2 cc. doses into posterior palatine, mental, mandibular, and infraorbital foramina, and subcutaneous and submucous regions. Marked rises followed anterior palatine and mandibular injections; all injections gave considerable rises. Dogs with intact vagi showed marked cardiac inhibitory effects following sudden rises in blood pressure. Conclusions: 1. Rate of absorption of epinephrine dependent upon vascularity of site injected. 2. Two per cent procain-epinephrine (1:50,000) injections often raise blood pressure 80 per cent above normal. 3. One minute usually

required, following procain-epinephrine injections, to attain height of blood pressure rise, 4–5 minutes for return to normal.

6. STUDIES ON PROCAINE POTENTIATION OF EPINEPHRINE. *Paul P. Pickering, D.D.S., B.S., and Arno B. Luckhardt, M.D., Ph.D., F.A.C.D., Walter G. Zoller Memorial Dental Clinic and the Department of Physiology, University of Chicago, Chicago, Ill.* To investigate possible sensitization of sympathetic system by procain hydrochloride to pressor effect of intravenous injections of epinephrine a series of standard injections of epinephrine hydrochloride were made intravenously into dogs anesthetized with ether or paraldehyde, as controls. These were followed by intravenous injections of procaine hydrochloride. Epinephrine hydrochloride solutions were again introduced into general circulation and rise in blood pressure noted. Drugs injected successively and not in combination. Conclusions: 1. Procaine hydrochloride, introduced intravenously into dogs anesthetized by paraldehyde or ether results in: (a) marked fall in general blood pressure; (b) decrease in rate and depth of respiration. 2. Procaine hydrochloride has no effect on pressor response to epinephrine when introduced in manner described.

7. INFLUENCE OF THE VASOCONSTRICTOR ON THE TOXICITY OF LOCAL ANESTHETICS. *M. L. Tainter, M.D., and A. H. Throndson, D.D.S., Department of Pharmacology, College of Physicians and Surgeons Dental School, San Francisco, Calif.* Toxicity of procaine solutions containing epinephrine, cobefrin or neosynephrine as vasoconstrictors, has been studied in experimental animals. Determinations were made of fatal doses in rats and cats, intravenously and intraperitoneally, with and without artificial respiration. Comparisons were made of effects of non-fatal quantities on blood pressure and respiration, when given subcutaneously, intramuscularly and intravenously.

8. DENTAL CONDITIONS IN CHILDREN WITH DISTURBANCES IN CALCIUM AND PHOSPHORUS METABOLISM. *Arild E. Hansen, M.D., Ph.D., Department of Pediatrics, Medical School, University of Minnesota, Minneapolis, Minn.* Metabolic studies were conducted in 3 types of clinical disorders associated with disturbances in calcium and phosphorus metabolism. In osteogenesis imperfecta histological studies of teeth and bones reveal that there is congenital failure of mesen-

chymal tissues to develop normally. In spite of extreme degree of osteoporosis of skeletal structures, teeth showed no particular or characteristic gross or radiographic changes. Investigations disclosed that but $\frac{1}{3}$ the amount of calcium and phosphorus was retained as was found in normal subjects under similar conditions. Mineral exchange studies, as well as serum minerals and plasma phosphatase activity determinations, were made at various intervals; the effect on these factors of such substances as vitamin D and parathyroid extract administration were noted. In a severe decalcification of skeleton due to primary carcinoma of liver in 10 year boy on whom metabolic studies were made, clinical examination showed no evidence of disturbance of teeth. In hypoparathyroidism where bone appears essentially normal, marked degree of hypoplasia with enamel defects and many carious teeth were found. Studies are underway to correlate condition of teeth by means of chemical analysis with the nature of calcium and phosphorus metabolism in various types of disturbances.

9. SIGNIFICANCE OF ROUGH COLONIES OF STREPTOCOCCUS VIRIDANS IN DENTAL CARIES. *Ruth Tunnicliff, A.B., M.D., and Carolyn Hammond, B.S., A.M., The John McCormick Institute for Infectious Diseases and the Foundation for Dental Research, Chicago College of Dental Surgery, Loyola University, Chicago, Ill.* Rough colonies generally associated with smooth colonies of *Streptococcus viridans* have been isolated from pulps and dentin of carious teeth. Bacillary, crescent, coiled, straight or wavy filamentous forms in rough, greening colonies change into cocci in pairs or short chains forming smooth colonies. Smooth cultures may be changed to rough. Rough cultures produce less acid (pH 5.2–6.0), than smooth (pH 4.4–4.8) in 1 per cent dextrose broth, pH 7.0. Both rough and smooth organisms grow in acid, 1 per cent dextrose broth (pH 4.4–5.0). Cocci, bacilli, crescents and undulating filaments found in smooth or rough colonies of *Streptococcus viridans* are, therefore, different forms of 1 organism and appear to correspond to cocci, bacilli and tortuous filaments described by Miller (1889) in tubules of carious teeth and considered by him to be a mixed infection. (*Arch. Path.* **26**:61, 1938)

10. TEMPEROMANDIBULAR JOINT ROENTGENOGRAPHY. NEW APPARATUS FOR REPRODUCING ROENTGENOGRAMS. *S. G. Balkin, M.D.,*

*D.D.S., Dental School, University of Minnesota, Minneapolis, Minn.*
(No manuscript received for publication.)

VI. SECOND SESSION: AFTERNOON, MARCH 12; ABSTRACTS 11–20

11. FACTORS INVOLVED IN VARIABILITY IN HARDNESS OF TOOTH STRUCTURES. *Harold N. Wright, M. S., Ph.D., and E. L. Fenske, D.D.S., Department of Pharmacology, Medical School, University of Minnesota, Minneapolis, Minn.* Comparative hardness determined by extent of abrasion under constant load. Statistical analysis of 208 teeth tested at cemento-enamel junction showed no relationship between hardness and anatomical position. Analysis by age groups showed extensive increase in hardness with age in females, slight but consistent increase in males. Mean abrasion values for sexes not significantly different. 105 teeth tested on dentine showed no relationship between hardness and anatomical position. Analysis by sex and age groups showed dentine in females significantly harder than in males, both sexes showing variation with age; maximum hardness between ages 31–40. Teeth extracted from same individual more nearly alike in hardness than teeth in same anatomical positions from different individuals. Further analyses in progress.

12. PRELIMINARY REPORT ON MOUSE TUMORS OF DENTAL ORIGIN. *J. R. Blayney, D.D.S., M.S., Walter G. Zoller Memorial Dental Clinic, University of Chicago, Chicago, Ill.* Routine study of mouse tumors in Cancer Laboratory of Otho S. A. Sprague Institute disclosed a number of mandible neoplasms, many not observed until autopsy. In other instances lower incisors were malposed so as to make eating impossible. No metastases of these tumors observed. Diet was adequate and well balanced and clinical history negative up to time of fatal illness. Serial celloidin sections made of entire head to determine tumor relationships and origin. These are epithelial tumors arising from reduced enamel epithelium of mandibular incisors, not found arising from mandibular molars or in maxillae. All cases studied to date are bilateral. The epithelium is squamous in type and apparently malignant, in places thickened, in others in form of long fingers extending from enamel organ. Pearl like formations and cystic changes are common. In occasional instances, on one side tumor is solid, on the other cystic. In one case tumor proliferation

has replaced most bone to head of the condyle. Clinical and histologic characteristics of these tumors closely parallels those of human ameloblastoma. Further study may yield additional information regarding this condition in man.

13. EXTRACTION INSTRUMENTS AND A CRANIAL ELEVATOR DERIVED FROM A COOPER'S TOOL. *George B. Denton, Ph.D., Dental School, Northwestern University, Chicago, Ill.* A cooper's tool, known as the *tiretoir*, (as shown by Sudhoff) furnished model for 2 extraction instruments, straight lever and pelican, introduced about the beginning of the XIV century. These instruments were probably brought into dentistry by skilled artisans, and largely employed for extraction until the end of the XVIII century. In 1579 Ambroise Paré introduced into cranial surgery an elevator, for raising bone in cases of depressed skull fracture, which was very much like the straight lever of his time. Paré, a barber for greater part of his life, probably adapted the dental extraction instrument for this purpose. The straight lever and Paré's elevator maintained similar design to end of XVIII century. This evolution of instruments points toward an influence of early dentistry upon surgery, rather than development of dentistry as a specialty from surgery.

14. DIETS OF ADOLESCENTS. *F. H. Cushman, D.M.D., and J. W. Etherington, D.M.D., Dental School, Harvard University, Boston, Mass.* Qualitative and quantitative analyses of diets of 67 lower-middle class patients, ages 13–19 years, were made. This age group was studied because it is characterized by rapid physical growth, high energy expenditure and high incidence of caries. It was thought that it might afford opportunity for observations of diets on the borderline of deficiencies. Outstanding were the following observations: (1) Low caloric intake (Av. 1735 calories), apparently not an economic phenomenon. (2) Good distribution of proteins, fats and carbohydrates. (Av. proteins, 15.2 per cent; fats, 38.7 per cent; carbohydrates, 45.1 per cent). Note that these are not high carbohydrate diets. (3) Low but well-proportioned calcium and phosphorus intakes. (Av. calcium, 0.80 grams; phosphorus, 1.12 grams) Deficiency due both to quantity and quality of foods. (4) Relatively adequate intake of iron. (Av. 0.014 grams). (5) Borderline intake

of vitamin C, definite and general deficiency of vitamin D. (6) Diets very generally basic in end-reaction. (7) Diets almost without exception of sticky consistency and low detergent value.

15. RATE OF SECRETION OF SALIVA AND INCIDENCE OF DENTAL CARIES. *Harry C. Trimble, Ph.D., James W. Etherington, D.M.D., and Paul K. Losch, D.D.S., Dental School, Harvard University, Boston, Mass.* In 244 experiments with 107 dental students the quantity of saliva secreted during 15 minutes was determined; paraffin was chewed to stimulate flow. Average secretion was 34 cc. per 15 minutes and amounts ranged from 9 to 68 cc. Curve of distribution bell-shaped. In group of 41 repeating test after interval of two weeks, quantity of secretion did not vary more than ± 5 cc. in 68 per cent of group. Similar reproducibility was observed for larger group when re-tested after 6 months. For 107 students condition of teeth was determined and recorded by 2 observers. After 12 months re-examination made. Of the 57 students having less than average rate of saliva secretion, 28 developed new smooth surface cavities during this period. Lower the secretion rate, more frequent was incidence of new cavities. In group of 50 having secretion rate greater than average, only 15 developed new cavities. Observations indicate rate of saliva secretion is 1 factor in caries incidence.

16. PROCEDURE FOR RECORDING FACE GROWTH AND CHANGES IN DENTITION. *Herbert I. Margolis, D.M.D., Dental School, Harvard University, Boston, Mass.* This original procedure consists of the following: (1) Profile and posterior radiographs of head standardized by means of adjustable cephalostat. Cephalostat also permits construction of other standardized radiographs at different angles from zero to 180 degrees. (2) Steroscopic camera with matched lens and single focus for construction of standardized stereoscopic photographs. (3) Facial dental cast of 3 areas of face (tragion, nasion, tragion) and dentition obtained by means of an adjustable precision facial dental tray. (4) Relating table for establishment in accurate manner 3 planes on model in relation to drawing board. (5) Precision projection device which by means of system of indirect projection makes possible immediate construction of records on various planes. Superimpositions of these records indicate in detail changes in 3 dimensions.

Clinical applications of this procedure were demonstrated; in showing growth and development of face and cranium and in detailed and precise description of changes during orthodontic treatment.

17. GROWTH AND DEVELOPMENT OF DENTAL ARCHES. *Joseph T. Cohen, D.D.S., Institute of Child Welfare, University of Minnesota, Minneapolis, Minn.* Measurements of lateral growth made from series of 12 casts taken from the same boy (one of 158 children studied in the same way). Casts taken at fairly regular yearly intervals; the first at age of 3 years, 10 months, and last at 15 years, 6 months. In general, there seems to be steady lateral growth of arches with occasional dip. Most definite period of growth appears to be between 10 and 12 years of age. This represents the transitional period of deciduous canines and molars and this fact may influence rapid growth at this time.

18. STUDIES OF PREMATURE ERUPTION OF PERMANENT TEETH IN CASES OF OSTEOMYELITIS, DENTIGEROUS CYSTS, GIANT CELL TUMORS, ETC. CONSIDERATIONS OF GIANT CELL TUMORS WITH SPECIAL REFERENCE TO ETIOLOGY. *Carl W. Waldron, M.D., D.D.S., Dental School, University of Minnesota, Minneapolis, Minn.* (No manuscript received for publication.)

19. INCIDENCE OF EXTRACTION IN CHILDREN'S DENTISTRY. **Charles L. Drain, D.D.S., and Virgil D. Cheyne, B.A., D.D.S., Dental School, Iowa State University, Iowa City, Iowa and Medical-Dental School, University of Rochester, Rochester, N. Y.* Problem of pedodontist as regards treatment or extraction is difficult and influence on final occlusion of teeth when permanent dentition is complete, is frequently of vital concern to the orthodontist. Statistics on early loss are presented from 10,644 individual examination records from files of Dental School of Iowa State University. Sex and age groupings are presented. Two aspects are considered, first, teeth lost before normal shedding time, and second, those teeth indicated for extraction becaase of abnormal retention. Data includes incidence of loss of first permanent molars.

20. OBSERVATIONS ON PERIPHERAL MYELINATED NERVES FOLLOWING LOCAL INJECTION OF (1) ISOTONIC SOLUTIONS OF VARYING pH AND

*Deceased.

(2) "ISO-pH" SOLUTIONS OF VARYING TONICITY. *H. M. Weaver, A.B., M.Sc. and P.C. Kitchin, B.S., M.S., D.D.S., F.A.C.D., Medical and Dental Schools, Ohio State University, Columbus, Ohio.* Experiment devised to ascertain effect on tissues of pH and osmotic pressure values in local anesthetic solutions. Range of pH values of solutions—4.37 to 8.77; osmotic pressure values from that of distilled water to that of 0.9 NaCl solution. Concluded: (1) When pH values of solution does not extend beyond 4.37 to 8.77 does not, in itself, cause any observable morphologic changes in peripheral nerve fibers of cat. (2) When osmotic pressure of solutions extend between that of distilled water and 0.9 NaCl solution is not primary causal factor of any observable morphologic changes in peripheral nerve fibers of cat. (3) Although neither pH nor osmotic pressure values, within indicated ranges, could in themselves be shown to be responsible for any described morphologic changes, evidence was presented indicating that combination of these 2 factors might be responsible for more severe changes. (To be published in J. D. Res.)

## VII. THIRD SESSION: EVENING, MARCH 12: ABSTRACTS 21–28

21. FURTHER STUDIES ON RELATIONSHIP OF FLUORINE CONTENT OF ENAMEL AND RESISTANCE TO DENTAL DECAY. *W. D. Armstong, Ph.D., M.D., and P. J. Brekhus, B.A., D.D.S., F.A.C.D., Dental School, University of Minnesota, Minneapolis, Minn.* The observation, previously reported, indicating that fluorine content of enamel of sound teeth is higher than that of carious teeth has been confirmed. Mean fluorine contents of enamel of sound and carious teeth are, respectively, 0.0111 and 0.0069 per cent. Fluorine content of dentin is higher than that of enamel and there is no correlation between amount of fluorine in dentin and condition of tooth.

22. ACCURACY OF CLINICAL AND ROENTGENOLOGIC DIAGNOSIS OF DENTAL CARIES AS DETERMINED BY MICROSCOPIC STUDIES. *Lester W. Burket, B.S., D.D.S., M.D., Dental School, University of Pennsylvania, Philadelphia, Pa.* Comparative gross, microscopic and roentgenologic examinations for caries made on 460 teeth. Caries more often detected by careful clinical examination than by use of roentgenograms. Roentgen ray was a greater aid in determining interproximal than occlusal caries. Both clinical and roentgenologic

examinations failed in diagnosis of 24 per cent of cavities demonstrated in microscopic preparations.

23. CARBOHYDRATE DEGRADATION BY MOUTH ORGANISMS, I. *Leonard S. Fosdick, Ph.D., Dental School, Northwestern University, Chicago, Ill.* Glucose allowed to ferment in saliva tricalcium phosphate medium. Acids of fermentation were isolated and identified as: hexose phosphoric acid, phosphoglyceric acid, pyruvic acid, lactic acid, acetic acid and butyric acid. On basis of acids isolated it was suggested that path of fermentation by mouth organisms is similar to production of lactic acid by tissue enzymes and production of alcohol by yeast enzymes.

24. DEGRADATION OF CARBOHYDRATES BY MOUTH YEAST "A". *George D. Wessenger, M.S., and Leonard S. Fosdick, Ph.D., Dental School, Northwestern University, Chicago, Ill.* Source of lactic acid in mouth and precise mechanism by which produced is considered. Suggested that chemical reactions involved production of lactic acid from glucose by mouth organisms are entirely analogous to the Meyerhof scheme for production of lactic acid in muscle. Determined ability of yeast "A," isolated from mouth, to carry out each of these reactions separately. Found that yeast "A" can promote each of these reactions but rate of reaction differs considerably. When rates of each of these reactions have been worked out for other mouth organisms hoped that information obtained will provide theoretical basis for predicting which organisms will produce largest amount of lactic acid and greatest amount of decalcification.

25. PRODUCTION AND CHARACTERISTICS OF SYNTHETIC MUCIN PLAQUES. *E. E. Campaigne, B.S., and L. S. Fosdick, Ph.D., Dental School, Northwestern University, Chicago, Ill.* Synthetic plaques prepared in laboratory. Visual inspection of plaques showed them of 2 types, borne out by pH determinations and nitrogen analysis. Visual and analytical comparisons made with real mouth plaques. Apparently several types exist in the mouth. Micro-method of attacking plaque problem is proposed.

26. STUDIES ON DENTAL CARIES. V. FAMILIAL RESEMBLANCES IN THE CARIES EXPERIENCE OF SIBLINGS. *Henry Klein, D.D.S., and Carroll E. Palmer, M.D., National Institute of Health, United States Public Health Service, Washington, D. C.* From dental examination

records on 4,416 grade school children, 2 groups of records were selected; one of children showing no objective evidence of dental caries experience in their permanent teeth, the other of children having evidence of severe dental caries experience. Dental records of brothers and sisters of these 2 groups of "index cases" were collected and dental findings in these siblings tabulated and analyzed. Findings clearly indicate that siblings of high caries experience children have of the order of twice as much caries experience as do the siblings of caries-free children. (Published in *Public Health Reports* **53**: 1353, 1938).

27. MICROCHEMICAL STUDIES OF SOME ZONES OF CARIES. *Richard S. Manly, M.A., Medical Dental School, University of Rochester, Rochester, N. Y.* Method is described for sampling and analysis of 2 zones of caries, and 1 control zone from dentin of 0.5 mm. tooth slabs. Carious zones were found to be from 0 to 90 per cent decalcified on different teeth; small caries had suffered less decalcification than large ones; no change could be demonstrated in Ca/P ratio when compared with control on the same tooth. With possible exception of moisture content, no chemical change could be found in the transparent carious zone.

28. DISTRIBUTION OF INORGANIC SALTS IN THE CELLS OF THE DEVELOPING ENAMEL ORGAN. *Edward G. Hampp, D.D.S., Dental School, Washington University, St. Louis, Mo.* The Policard-Scott method of incineration used to determine localization and distribution of the total mineral elements as they exist in living cell. Recognition of individual elements in ashed preparation is facilitated by their structure and characteristic coloration. During differentiation of enamel organ from oral epithelium definite changes observed in mineral elements of proliferating cells, in both nucleus and cytoplasm. Minerals not stationary but exhibit large increases in some elements and diminution of others. During formation of enamel organ, before cells differentiate into layers of mature organ, there is rapid and continual increase in amounts of white ash of calcium and magnesium corresponding to blue staining portion of nucleoplasm and to lesser extent cytoplasm in hemotoxylin-eosin control. There is steady increase in amount of bluish white ash of sodium and potassium in the cytoplasm of epithelial derivatives reaching maximum in mature

organ. Iron, recognized by yellow to red coloration, present in varying amounts and confined chiefly to nucleus; in some instances, entirely absent. Total amount, type and localization of various mineral elements depends on functional stage of cells comprising enamel organ.

## VIII. Fourth Session: Morning, March 13; Abstracts 29–39

29. Healing of experimental tooth fractures. *Roland S. Claflin, D.D.S., M.D.S., Foundation for Dental Research of the Chicago College of Dental Surgery, Loyola University, Chicago, Ill.* Tissue changes around apices of dogs' teeth studied *in situ*. Apices had been broken off in attempts to extract teeth. Observation time varied from 3 days to 1 month. In all cases in which fracture line was well below surface of jaw, pulp in root fragments remained vital, and tissues closed over fragments without inflammatory reaction. Alveolar bone grew across fractured surface. Periodontal membrane was preserved but had lost functional arrangement. Comparison with human apices remaining in jaws under similar circumstances reveals complete analogy between tissue changes in man and dog.

30. Coronal cementum and resorption. *Rudolf Kronfeld, M.D., D.D.S., Foundation for Dental Research of the Chicago College of Dental Surgery, Loyola University, Chicago, Ill.* Formation of cementum in occlusal fissures was studied in serial sections through young human jaws containing unerupted permanent molars. Cementum found either in form of large cementicles lying in tooth follicle or as actual deposition of cementum upon enamel at bottom of fissure. Occasionally, before eruption, resorption takes place in enamel of teeth; then erupted tooth has irregular defects in enamel. Example is shown in which resorption extended through entire thickness of enamel of second permanent molar of an 8 year old child. (Published in *J. D. Res.* **17**: 151, 1938.)

31. Alveolar bone in pulp chamber. *M. S. Aisenberg, D.D.S., F.A.C.D., Dental School, University of Maryland, Baltimore, Md.* Presence of alveolar bone in teeth has been reported several times in past 15 years. Explanation of unusual condition has not been reported. From material showing repair in retained deciduous canine, fractured teeth and internal resorption, the following explanation is

offered: When adult connective tissue (periodontal membrane) invades pulp through fracture or as result of resorption it exhibits its potential powers of building secondary cementum or bone. Where the space is narrow, secondary cementum repairs surface. Where space is wide, alveolar-type bone with periodontal fibers attached to newly deposited secondary cementum on the dentinal surface will result. In some cases ankylosis occurs, especially when teeth are in good functional activity. (To be published in *J. D. Res.*)

32. METALS AND GALVANIC CURRENTS IN MOUTH. *Oscar Kanner, M.D., Foundation for Dental Research, Chicago College of Dental Surgery, Loyola University, Chicago, Ill.* In opinion of essayist, actual and continuous flow of galvanic currents in mouth, due to any spontaneous cause, has never been demonstrated; those who thought that they had found evidence of such currents, generated by dissimilar metallic restorations, might have been mistaken about fundamentals of electricity. If alleged currents exist at all, it would be necessary to show that they are capable of doing harm. It seems that such evidence is not available. Idea that bimetallic restorations cause injuries based upon 2 arbitrary assumptions, i.e., assumption that such restorations do generate currents, and, secondly, that these currents are responsible for certain lesions. It is concluded that up to present time there is no evidence to support either of these assumptions. Lesions in oral cavity may be caused by certain types of fillings or other restorations, but usefulness of introducing galvanic hypothesis seems quite problematic; it appears unreasonable to base any practical conclusion upon this hypothesis.

33. MATHEMATICAL ANALYSIS OF AMALGAM FLOW. *Eugene W. Skinner, Ph.D., Dental School, Northwestern University, Chicago, Ill.* Specimens of dental amalgam, homogenized at 60°C. for 3 months or more, tested for plastic flow in manner prescribed A. D. A. Specification No. 1, except temperature of 37°C. was employed. Curves obtained by plotting percentage flow as function of time; 24 hour period employed. Mathematical formulae for curves were found to be of form:

$$Y = At + B(1 - e^{-t/\mu})$$

where Y is percentage flow; t, time; and A, B, $\mu$ are parameters which depend upon composition, trituration, condensation, temperature, etc.

Analysis of above formula showed it identical with equation for extension with time of mechanical system which consists of piston in series with parallel connection consisting of another piston and spring. It was shown that partial recovery, or "redress" of system occurred after load was removed. Also demonstrated that coefficient of internal friction or viscosity and modulus of rigidity could be computed for amalgam from its flow curve. For given trial, preliminary experimental value for redress was found to be 0.21 percent, whereas theoretical value was 0.18 percent. Computed value for modulus of rigidity and coefficient of viscosity were $138 \times 10^9$ kg. per sq. cm. and 57.5 megapoises, respectively.

34. RELATIVE PERMEABILITY OF CASTING INVESTMENTS. *Raymond E. Myers, D.D.S., B.S., and K. R. Pfeiffer, D.D.S., School of Dentistry, University of Louisville, Louisville, Ky.* Relative permeability of casting investments determined by drawing air through sample of material and measuring time required for vacuum pressure, indicated by mercury manometer, to drop from one point to another. Manometer provided with electrical arrangement whereby differences in levels of mercury would convey break and make impulses to signal magnet for recording on kymograph. Tracing was accompanied by fifth-second interval recordings of chronograph, permitting accurate measurements to 0.1 second. Investment samples prepared in special, grooved-wall flasks provided with tapered stems which were machined to fit flask seat on machine and incased in water jacket. Vacuum reservoir was restricted to capacity of 3 cubic inches in order that permeability measurements could be made during interval of few seconds. Operation of valve between flask seat and vacuum reservoir allowed air to be drawn through sample. Obviously, more impermeable material, longer was time required to effect a decrease in vacuity. Thus, average time in seconds was taken as permeability factor. Tests were made at temperatures ranging between room and 800°C. Results on various investments will be published soon.

35. DISTORTION OF WAX PATTERNS AS INFLUENCED BY MANIPULATION. *R. L. Lasater, D.D.S., Dental School, Northwestern University, Chicago, Ill.* Distortion of wax patterns was studied by tracing optically projected enlarged images of patterns after manner of Maves. Distortion produced by changing temperature of water bath in which respective patterns were immersed. Found that uniform heating of

wax was imperative for production of minimum distortion. Furthermore, temperature of heating produced different types of distortion, depending whether it was above or below arrest temperatures given by time-temperature cooling curve for wax. This effect was very noticeable and it is suggested that time-temperature cooling curve might be included in routine tests. It was shown that least distortions occurred when wax was heated in dry air at temperature below principal arrest temperatures. Theory was presented to account for these distortions.

36. INVESTIGATION OF ELECTRO-CONDUCTIVE IMPRESSION MATERIAL. *G. Earl Thompson, D.M.D., Dental School, Harvard University, Boston, Mass.* Use of electro-conductive material in connection with technique for electro-forming of copper dies for construction of dental restorations would greatly facilitate such procedure, and increase usefulness of this otherwise simple and scientifically accurate technique. Experiments with one such material consisting of 55 per cent fine graphite and 45 per cent paraffine (mp. 54.5° C.), by weight, a combination which is usable in practical cases, yielded following results: (a) Working temperature, 51.6 to 54.4° C. (b) Viscosity test (bar suspended at either end, center sag measured): Bar size, 100 x 5 x 5 mm.; room temperature, 21.1 to 23.8° C.; amount of sag, 0.217 mm. Sag for a commonly used compound, same conditions, 0.174 mm. (c) Plasticity test (Forcing material at definite temperature into graduated glass tube). 24 tests at 54.4° C., pressure 0.86 Kg.; average distance of flow of graphite wax without lubrication of tube wall, 103.7 units; average flow of compound with lubrication of all walls, 96 units. (d) Coefficient of expansion (comparison microscope) taken between 20.5 and $40°_{m}$ C., $215.9 \times 10^{-6}$ degrees C. (e) Numerous tests made to determine whether detail was lost in plating process, but no measurable result.

37. RATE AND GRADIENTS OF GROWTH IN RAT MOLAR AS DEMONSTRATED BY INJECTIONS OF ALIZARINE RED S. *M. M. Hoffman, B.S., D.D.S., and Isaac Schour, B.S., D.D.S., M.S., Ph.D., Dental School, University of Illinois, Chicago, Ill.* Forty albino rats, 1 to 100 days old, given multiple intraperitoneal injections of 0.03–1.0 cc. of 2 per cent alizarine Red S (Coleman and Bell) at intervals of 7 to 14 days, and killed at 40, 60, 80, and 100 days of age. Dosage range, 39–140 mgms. per kgm. Ground sections of molars showed red line in dentin

calcifying at time of each injection. Rate of dentin apposition per 24 hours obtained by measuring distance between successive red lines and dividing by intervening number of days. Growth gradients decrease from tips of cusps to apices; from dentinal surfaces to pulp; and spirally toward a center. First molars showed maximum daily appositional rate of 15.80$\mu$ $\pm$.46 and minimum of 1.22$\mu$ $\pm$.74. At 100 days of age dentin growth of first molar still proceeded pulpally in roof and floor of pulp chamber but had ceased along long axis. Red lines of appositional growth were also present in alveolar bone and cementum. Rate of dentin growth was independent of weight and general condition. Experiments now conducted to determine relation of appositional growth lines in dentin, cementum, and bone to rate and process of eruption.

38. ANTIBACTERIAL AGENTS IN HUMAN SALIVA. *Basil G. Bibby, B.D.S., Ph.D., School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* Salivary antibacterial agent effective against *Micrococcus lysodeikticus, Bacillus megatherium,* and sarcina will not pass Berkefeld filter, is only slightly weakened by temperatures of 75°C. for 5 minutes, resisting 100°C. for 15 minutes, is destroyed by ultra-violet radiation, is inactivated by storage for 12 days at 20°C. and 24 hours at 37°C. but survives 2 months refrigeration (8°C.), is adsorbed on kaolin and charcoal, but not on aluminum oxide, is completely precipitated by acetone and partially precipitated by acid. The agent effective against staphylococci, streptococci, lactobacilli, and colon-typhoid organisms, passes Berkefeld filter, is destroyed in 5 minutes by temperatures of 75°C.; resists ultra-violet radiation; survives 2 months refrigeration and 24 hours incubation; is adsorbed on kaolin and charcoal but not on aluminum oxide; is only partially precipitated by acetone and is completely inactivated by acid. Properties of lysozyme of egg white resemble those of first agent but lysozyme passes filter, survives ultra-violet radiation and storage at 20° and 37°C. Amylase, on the other hand, bears more resemblance to second antibacterial agent and its properties differ in no essential detail.

39. ASCORBIC BLOOD LEVELS IN DENTAL PATIENTS. *David Weisberger, M.D., D.M.D., Dental School, Harvard University, Boston, Mass.* Ascorbutic acid blood levels studied in 65 patients; feeding experiments were carried out on 15 of these. It is concluded that (1)

partial vitamin C deficiency causes some degree of parodontal disease, and (2) replenishment of vitamin C is followed by normal ascorbutic blood levels and clinical improvement in the tissues affected. (Published in *J. D. Res.* **17:** 101, 1938.)

## IX. Fifth Session: Afternoon, March 13; Abstracts 40–52

40. Effects of daily use of flavored sodium perborate as a dentifrice for six months. *Charles F. Bodecker, D.D.S., F.A.C.D., and Lester R. Cahn, D.D.S., Dental School, Columbia University, New York, N. Y.* Purpose of investigation to determine whether prolonged use of flavored sodium perborate causes chemical burns, "hairy tongue," or edematous conditions of oral mucosa. One hundred students used sodium perborate as a dentifrice for 6 months. All mouths photographed in colors in order to have permanent evidence of any pathological changes, also gingival biopsies of 20 and blood examinations of 37 students were made. Four students developed lesions suggestive of tooth brush trauma which did not reappear when use of sodium perborate was resumed. No pathological conditions were noted which could be defined as chemical burns of oral mucosa, "hairy tongue," or edema of mucosa. Flavored sodium perborate was not harmful to oral mucosa of this experimental group when used as dentifrice twice a day for an extended period. (Published in *J. D. Res.* **17:** 161, 1938.)

41. Concerning vitality of calcified dental tissues, II: permeability of enamel. *William Lefkowitz, D.D.S., and Charles F. Bodecker, D.D.S., F.A.C.D., Dental School, Columbia University, N. Y.* Evidence advanced by authors that stains can penetrate normal enamel from within, through agency of dental lymph, but not from without-inward. Only as a result of certain changes such as action of dental cement on enamel of dogs does enamel become permeable from without-inward. Action of dental cement on surface of enamel appears to break down surface impermeability, permitting stain particles to be carried into enamel and dentin by dental lymph. Stain demonstrated in cracks in human enamel. Enamel also possesses function of retaining dental lymph within tooth. Normal enamel appears to possess protective function similar to that of skin; in teeth of dogs and young persons it is permeable from dentino-enamel junction to surface of enamel, but not from without-inward, thereby classi-

fying enamel and skin as uni-directional permeable membranes. Establishment of impermeability of enamel from without-in seems to preclude possibility of post-eruptive calcification of normal enamel by means of deposition of mineral salts present in saliva.

42. STRENGTH OF BITE OF PRIMITIVE ALASKAN INDIANS. *L. M. Waugh, D.D.S., F.A.C.D., Dental School, Columbia University, New York, N. Y.* (No manuscript received for publication.)

43. VASCULAR CHANGES IN INFLAMED DENTAL PULP. *Leroy R. Boling, Ph.D., and Hamilton B. G. Robinson, D.D.S., M.S., Dental School, Washington University, St. Louis, Mo.* Self-strangulation of inflamed pulp usually explained as result of increased arterial pressure occluding vein at apical foramen. This is invalid because (1) pulp may have several afferent and efferent vessels and separate foramina; (2) does not explain changes in multi-rooted teeth; (3) pulpal blood flows through a closed hydrostatic system, pressure in vein soon will equal that in artery. In inflammation permeability of vessel walls increases; osmotic phenomena lead to edema. Edematous cells enclosed in rigid dentinal box can only swell against vessel walls, retard flow of blood and lead to thrombosis. These changes demonstrated *in vitro* by constructing glass "tooth" in a narrow-necked, tightly stoppered flask and glass "muscle" in an open beaker. These were filled with 0.75 per cent agar solution with 20 per cent added sugar; semipermeable celloidin tubes passing through the solutions were connected in shunt with water supply at pressure of 100 mm. of mercury. Readings taken of time required for 1000 cc. of water to pass through each solution as follows:

| | "Tooth" | "Muscle" |
|---|---|---|
| Beginning of experiment | 143 sec. | 154 sec. |
| End of 24 hours | 2005 | 161 |
| End of 5 days | 45179 | 162 |
| Pressure released in tooth | 133 | 154 |

Self-strangulation of inflamed pulp can be explained rationally as result of swelling of edematous pulp tissues against blood vessels leading to thrombosis and eventual pulp death.

44. CALCIFICATION OF DENTIN FOLLOWING PARATHYROIDECTOMY. *Gerrit Bevelander, Ph.D., and Margaret Hoskins, Ph.D., Dental School, New York University, New York, N. Y.* To supplement and clarify problem of tooth calcification, study of process has been undertaken

in constantly developing incisor of rat. Operative procedure involving removal of parathyroid glands used as means of initiating profound disturbances of calcium metabolism and subsequent calcification of dentin. Madder used in animal diets as means of identifying portion of dentin laid down during calcification disturbances. Examination of teeth following operation reveals lesions of severe intensity in post-operative dentin. Considerable variation in morphology of this dentin occurs not only in different animals but in different parts of same tooth. Determination of blood calcium is being made in an attempt to correlate changes in these values with production of abnormal dentin. No evidence that submaxillary glands play any rôle in calcification disturbance can be found from these experiments.

45. BACTERIOLOGY OF PULP INVOLVED TEETH. *Fred W. Morse, Jr., M.D., Morton F. Yates, D.M.D., and Paul L. Thayer, D.M.D., Dental School, Harvard University, Boston, Mass.* In each case treated by students over 3 year period an old and new dressing were cultured at each visit of patient; final filling of canal was done only after 2 consecutive negative cultures. Cultures made in 1 per cent dextrose infusion broth, pH 7.6, positive tubes transplanted onto blood agar. Aerobic conditions only prevailed during incubation. At each visit dressings sealed in with cement. Of the cases, 105 (29.8 per cent) revealed no aerobic bacterial infection. Remaining 247 cases could be divided into single and multiple infection groups. Single infection group responded promptly to treatment. Gamma streptococci were present in 50 per cent of single infections and 35 per cent of multiple infections. Of all the cases 11 per cent showed presence of aciduric bacilli; alpha streptococci and yeast were each present in 10 per cent of multiple infection group. Beta streptococci were found only in 1 per cent of all cases.

46. VASCULARITY OF HUMAN ENAMEL ORGAN. *Ellis B. Jump, D.M.D., Children's Hospital and Dental School, Harvard University, Boston, Mass.* Most texts of dental histology deny vascular penetration of human enamel organ. Routine examination of portions of mandibles removed post mortem reveals presence of capillaries in stellate reticulum of posterior teeth in patients up to 14 months with a variety of diseases. Blood vessels enter reticulum near tips of cusps approximately when amelogenesis begins. Later, vessels pierce reticulum over central fossae. Process is initiated by formation of papillae

in outer epithelium in close relation to vascular plexus from dental capsule. Vessels then penetrate stellate reticulum, and lie within large perivascular spaces immediately beneath outer epithelium. As reticulum narrows, vessels lie nearer stratum intermedium. With disappearance of reticulum, capillaries invade stratum intermedium and approach to within 10$\mu$ of ameloblasts. In 1 patient blood vessels were found within enamel organs of deciduous second incisor and canine in addition to those of posterior teeth. Assumed that vascularization closely associated with amelogenesis. Amount of vascular penetration and time when it occurs in any species depends on relative areas of ameloblastic and outer epithelial layers, amount of stellate reticulum, and degree of development of a papillary layer in outer epithelium to increase absorbing surface of capsular capillary plexus. (To be published in *J. D. Res.*)

47. SOME PRELIMINARY STUDIES IN CALCIFICATION USING RADIOACTIVE PHOSPHORUS. *Marian L. LeFevre, M.S., and William Bale, Ph.D., School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* Single dose of radioactive phosphorus fed by stomach tube to each of 6 male rats. At various times after dose, rats sacrificed, bones and teeth removed, glycol extracted, and percentage of original dose found in each of tissues determined. Measurable amount of the phosphorus was found in inorganic portion of fully erupted molars after 4 hours in both growing and adult rats. The rapidly growing incisors contained progressively larger amounts from tip to root and high percentages of the phosphorus were found in bones.

48. QUESTION OF DIFFERENCE IN MOLECULAR COMPOSITION OF MINERAL PHASE OF ENAMEL AND DENTINE. *Harold C. Hodge, Ph.D., School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* Certain evidence points to identity of principal molecules found in enamel and dentine. (1) X-ray diffraction patterns are apparently identical. (2) Electrometric titrations show that stable precipitated phase of calcium and phosphorus (from water at pH's above approximately 6) is hydroxylapatite. On the other hand, chemical differences in composition are well established, dentine containing more carbonate, magnesium and potassium. Calcium and phosphorus percentages of inorganic part are nearly same in both tissues. Two hypothyses are offered to harmonize chemical differences

with fundamental similarities. Each hypothesis indicates fundamental lattice to be that of hydroxylapatite. One hypothesis (Armstrong et al.) accounts for the carbonates by isomorphous replacement of calcium and phosphorus by carbon in different amounts for the 2 tissues. Other assumes that enamel and dentine mineral phases are coacervated particles of hydroxylapatite with occluded, adsorbed or interstitially crystallized carbonates and other salts; enamel may differ from dentine only in quantities of these latter materials around particles of hydroxylapatite.

49. ROENTGENOGRAPHIC STUDY OF TONGUE POSITION. *John R. Thompson, D.D.S., B.S.D., M.S.D., Dental School Northwestern University, Chicago, Ill.* Outline of dorsal surface of tongue obtained by small link gold chain, one end of which was swallowed by patient; care was taken to see that chain occupied median sulcus of tongue. Outline of soft tissues covering hard palate was obtained by adapting thin strip of tin foil over median line. Lateral profile roentgenograms were then made as follows: (1) immediately after swallowing: (2) ½ minute after swallowing: (3) 1 minute after swallowing: (4) 2 minutes after swallowing. Immediately after swallowing the tongue is in contact with the palate in 87 per cent of cases. One-half minute after swallowing, the tongue was in contact with the palate in 73 per cent; after 1 minute, in only 35 per cent; and after 2 minutes, in 40 per cent. Apparently tongue should normally be against palate immediately after swallowing, but it shortly drops away and negative pressure cannot then exist. Results of this study do not agree with general belief that vacuum space exists between tongue and posterior portion of hard palate and that vacuum or negative pressure is important factor in maintenance of mandible in its rest position. (Published in *Angle Orthodontist*, **8:** 100, 1938.)

50. INFLUENCE OF BREAD NUTRITION IN GERMANY AND SWITZERLAND UPON DEVELOPMENT OF CARIES, CALCULUS AND FILM, DUE TO A CERTAIN METHOD OF FEEDING. *Gustav G. Haber, M.D., German Research Community.* Group of 40 children, age 4 to 12 years observed for 27 to 46 months under same living and food conditions except as described. They were divided into 2 parts of 20 each. To one was given soft, 80 to 83 per cent ordinary rye bread, baked at usual high temperature in loaf form with hard crusts and soft centers. To second

group was supplied 100 per cent rye bread in form of flat cakes, *Knaekebread*, grain ground by special process and bread baked at low temperature in form of flat cakes. Caries of deciduous teeth developed twice as quickly in soft bread group compared with hard bread group; there was 1½ to 3 times more caries in soft bread group than in hard bread one. After 2 years of this experiment, average chewing strength of hard bread group was 22 per cent higher than that of soft bread unit. Knaekebread children had a more copious salivary flow with increased alkalinity and greater increases in body height and weight than those in soft bread group.

51. DETERMINATION OF HALITOSIS BY MEANS OF OSMOSCOPE AND CRYOSCOPIC METHOD. *Robert H. Brening, D.D.S., and Glenn F. Sulser, D.D.S., Dental School, Northwestern University, Chicago, Ill.* Following preliminary experiment, it was found that breath samples could be collected by "freezing out" process, using liquid nitrogen as freezing agent. Patient breathes through apparatus containing liquid nitrogen (−210°C.) for given time—15 minutes. At this temperature breath constituents are frozen out in collecting tube. Sample is brought to 37.5°C. in water bath and tested for odor by osmoscope. Osmoscope readings are termed pO values and range from 0 to 6, higher number indicating more intense odor. Semi-quantitative tests are run on condensate for indole, aldehydes, furfural, sulfur and ammonia. Chemical tests are correlated to some degree with clinical data, as nose and throat conditions, pyorrhoea, caries susceptibility, etc. Results show aldehydes, particularly furfural, together with high ammonia content are found in tobacco smoke samples. High pO values are often associated with pyorrhoea, while presence of caries apparently is not decisive factor in odor production. Odor intensity increases on average as age increases. Further work in progress.

52. PROSPECTIVE COMPILATION OF ESSENTIAL FINDINGS IN RESEARCH ON DENTAL CARIES. *William J. Gies, Ph.D., F.A.C.D., Columbia University, New York City.* Author announced, in absence of and for Chairman Lowery of Research Commission of A. D. A., that Commission will compile brief and direct summaries of basic findings by each investigator of cause or control of dental caries. Living observers will prepare their own summaries and specify only results regarded *now*, by each author, as fully indicating gist of his accumu-

lated work and abiding chief conclusions. Scope of authorship to be world-wide. All who have published findings of clinical observation or research will be invited to coöperate, in effort to make compilation comprehensive and complete without irrelevant data. Compilation, effectively organized and indexed including adequate references to all main publications, will be basis for clarification of current views and source of effective aid in further investigation—and for reliable use of findings by dental practitioners and all others concerned. Funds from philanthropic source will probably be made available for adequate publication and free distribution. Present author, as secretary of Advisory Committee, will conduct Commission's work in this relation.

## X. Sixth Session: Evening, March 13; Abstracts 53–61

### A. Greetings from representatives of dental organizations: abstracts 53–61

53. American college of dentists. *Charles E. Rudolph, D.D.S., F.A.C.D.* "The Minnesota section of the American College of Dentists is delighted to sponsor this occasion and appreciates the honor it has in doing so. It greets you in the name of the American College of Dentists and sincerely hopes that, in spite of some inconveniences you may have suffered and some you may yet experience, due to a trial and error method of practical solution of a great social problem in our city, you will not only enjoy your visit, but profit culturally and scientifically.

"There is no phase of progressive dental thinking which needs more nurturing and encouragement, especially among the youth of our profession, than that phase which you represent, and I deem it a great personal privilege to represent a dental group which has a major project *Dental Research.* It is obvious that the closest harmony between Dentistry and all professions, and especially Medicine proper, is not only desirable but absolutely necessary. The ramifications of Dental Research are such that we must make and keep friends in all scientific groups.

"May this be only one of many such meetings where scientists gather, and through their deliberations, be of great benefit to hu-

manity. Dentistry has always needed friendly criticism and counsel. It has not, and does not, lack these friends. May I salute our great counselor, Dr. William J. Gies, as an outstanding example, a personification of real devotion and friendship. Few among the great educators to date have taken a personal interest in dental problems. Tonight we are honored by the presence of one of those few who is taking a vital interest in dental progress, especially from the educational and research points of view. May I present Dean Guy Stanton Ford, acting President of the University of Minnesota."

54. UNIVERSITY OF MINNESOTA. *Guy Stanton Ford, Ph.D., LL.D., Litt.D., Acting President of the University of Minnesota and Dean of the Graduate School, Minneapolis, Minn.* The speaker for himself, the faculty and regents heartily welcomed the members of the Association and their guests to Minneapolis. He extended a cordial invitation to visit, not only the Dental School, but also other departments of the University, and expressed the University's great pleasure in having the opportunity to be host to the Association. He pledged the University's interest in dental research and education and described its efforts to promote work in this field.

55. MINNESOTA STATE DENTAL ASSOCIATION. *George Damon, D.D.S., President, Minneapolis, Minn.* "It is with pleasure, mingled with a certain degree of pride, that I respond to the invitation of your chairman to extend greetings and felicitations to the members of the International Association for Dental Research and their guests from the members of the Minnesota State Dental Association. We are pleased that 'at long last' you have come from the four corners of the earth to Minnesota, pleased that the membership of our association has been invited to participate in your scientific program, share in the benefits, and be stimulated by the many delightful personal contacts. The influence of this meeting is going to quicken the pace of research workers within our state and create in the membership at large a keener appreciation of the need."

The speaker described the activities of the state society and its journal, Northwest Dentistry, including an active interest in research problems, study clubs, and extension courses; a sympathetic attitude towards the establishment of the graduate school in Dentistry where the true research type may be developed. "In closing, let me pass on

to you from the members of the Minnesota State Dental Association that friendliness which should exist between groups united in a common quest for knowledge and the truth. Although the ideal will never be reached, the leaven which quickens professional growth is the contribution of its research workers."

56. UNIVERSITY OF MINNESOTA, SCHOOL OF DENTISTRY, *William F. Lasby, D.D.S., F.A.C.D., Dean, Minneapolis, Minn.* The speaker expressed the pleasure the faculty in the School of Dentistry was enjoying in having the Association meet in Minneapolis and the School's interest in the work of the Association. He extended a cordial invitation to all members and guests to visit the School and avail themselves of all its facilities to make their visit a memorable occasion.

57. UNIVERSITY OF MINNESOTA, SCHOOL OF MEDICINE. *Harold S. Diehl, M.A., M.D., Sc.D., Dean, Minneapolis, Minn.* The speaker extended the greetings of the medical faculty to the Association discussing especially the relationships between medicine and dentistry. He emphasized the close affiliation between the two fields especially where there is overlapping of research problems. He was impressed with the success of the Association in presenting a program for its annual meeting that included the work of physicians, biochemists, anatomists and pathologists as well as dentists, and hoped for a long and successful existence of the Association.

### B. ANNOUNCEMENT OF THE WILLIAM J. GIES RESEARCH FELLOWSHIPS OF THE AMERICAN COLLEGE OF DENTISTS

58. THE GIES DENTAL RESEARCH FELLOWSHIPS AND AWARDS FOR ACHIEVEMENT IN RESEARCH. *Albert L. Midgley, D.M.D., Sc.D., F.A.C.D., Chairman, Committee on Dental Research, American College of Dentists, Providence, R. I.* I have looked forward to this meeting as an opportunity to acknowledge our debt to the body of men who are engaged in applying the theories and practices of modern science to the solution of dental problems, and to the enlargement of professional outlook. Such activity not only improves our service to the public but also draws to our ranks the ablest personnel.

The American College of Dentists considers the promotion of re-

search one of its most important objects, and its Committee on Dental Research proposes to give substantial help to the cause by open and vigorous assertion of the claims of dental research upon public confidence and support. We believe that a convincing demonstration of these claims depends in part upon a close, effective, and mutually cordial medico-dental relationship, not only in professional and hospital practice but in the laboratory as well, where the interrelated problems of dentistry and medicine offer a basis for intimate cooperation and present a common point of view. Separate studies would be in no way neglected or subordinated, while a coordinated program of research in problems of value to both professions will provide stimulating rivalry and avoid duplication of effort.

Our direct promotion of research will be by grants from the William John Gies Fellowship Fund, to be effective on or after July 1, 1938; and by bestowal of the William John Gies Award in recognition of outstanding achievement, to be initiated in 1939, the centenary of dentistry as a separately organized profession. In presenting the claims of research with a view to securing endowment, in determining how the fellowship funds shall be administered, and in arranging an appropriate manner and occasion for the recognition of distinguished achievement in research, we invite the advice and assistance of a standing committee of the International Association for Dental Research.

I earnestly hope that our organizations will work together in full unity and confidence, carrying forward the ideals and purposes imparted to us by our beloved friend and benefactor, Dr. William John Gies. Vision supplemented by experience; ideals with the drive of practical initiative, will keep dentistry marching on to new fields of solid achievement.

### D. OFFICIAL ADDRESSES: 59–61

59. PRESIDENTIAL ADDRESS. *Paul C. Kitchin, B.S., M.S., D.D.S., Dental School, Ohio State University, Columbus, Ohio.* (Pages 274–290)

60. INTRODUCTION OF PRESIDENT-ELECT, *by Russell W. Bunting) D.D.Sc., F.A.C.D., Dental School, University of Michigan, Ann Arbor, Mich.* (Pages 290–291)

61. INAUGURAL ADDRESS. *Thomas J. Hill, D.D.S., F.A.C.D.,*

*Dental School, Western Reserve University, Cleveland, Ohio.* (Pages 291–292)

(Concluding executive proceedings followed: page 339)

## XI. Papers Read by Title: Abstracts 62–112

### A. Contributions by European Members not at Present Attached to Sections: Abstracts 62–64

62. Anacoric effect of chronic periapical inflammation. *Giulio Csernyei, M.D., Royal University of Bologna, Milan, Italy.* Chronic periapical infections produced in dogs by drilling into pulp chamber and extirpating whole pulp. After some weeks chronic periapical inflammation developed in each case. After this time dogs were inoculated intravenously with culture of Bang bacillus. Some weeks later dogs were killed and treated teeth extracted aseptically and periapical regions cultured; in every case Bang bacillus was recovered. In no case was Bang bacillus recovered from periapical regions of intact teeth from injected animals. These experiments demonstrate that periapical granulations attract infective microorganisms from circulation, that is they have an anacoric effect (anacoresis). Medicaments and methods of treating root canals that can provoke chronic inflammations in the periapical tissues are to be avoided absolutely, because by anacoresis they can become infected foci.

63. Aseptic treatment of devitalized teeth without root canal filling. *Giulio Csernyei, M.D., Anatomic-pathologic Institute of Ospedale Maggiore, Milan, Italy.* Ideal extirpation of the whole pulp is generally impossible. In apical portion of canal small particles of tissue and coagulated blood are found. If these remain sterile, migration of tissue elements from reticulo-endothelial system of the peridontium will result in their disintegration and replacement by connective tissue. Consequently it is essential to proceed aseptically; antiseptics and other foreign materials which can irritate the periodontium and produce chronic inflammation are not to be used. A method for obtaining these results is described.

64. Radix praemolarica unilateralis. *Theodor E. de Jonge-Cohen, M.D., Laboratory for Anatomy and Embryology of Professor M.*

*W. Woederman, Amsterdam, Holland.* An accessory root of a lower first molar is described and illustrated. This anomaly is unilateral in spite of perfect bilateral symmetry of the crowns of both lower first molar teeth. Such a malformation is discussed in connection with the assumption of Bolk that this defect represents an anomalous development of a rudimentary fourth premolar tooth germ long since extinct. The theory of bilateral symmetry is discussed and accepted. In instance presented both lower molar teeth are alike except for presence of accessory root on right side and this would seem to contradict the doctrine of bilateral symmetry. If however assumption is granted that accessory root has nothing in common genetically with first molar, and that it has developed independently and attached itself to the otherwise symmetrical molar teeth, there is no contradiction.

### B. CONTRIBUTIONS BY VIENNA SECTION: ABSTRACTS 65–74

65. NEW MIXTURE OF CEMENT AND METALS FOR FILLING DECIDUOUS TEETH. *Fritz Driak, M.D., Dental Institute (Prof. Dr. H. Pichler, Director), University of Vienna, Vienna, Austria.* Excellent properties of alloy and cement well known. To avoid disadvantages of these materials and to combine their good qualities with those of other materials, various mixtures were tested both in laboratory and clinic. These tests included; resistance to pressure, study of micro-structure, color, porosity, effect of saliva, and setting time. Mixtures of crown and bridge cements with metals were developed with properties unknown up to now and with greater resistance to deterioration than unmixed cements. Such a mixture of cement and alloy is splendidly adapted for filling cavities in deciduous teeth. It is produced under name of "*Amalgam-Zement Füllung.*"

66. WHAT HAPPENS TO DEAD CEMENTUM SURFACE AND ACCESSORY CANALS OF INFECTED TEETH? *B. Gottlieb, M.D., Dental Institute (Director, Prof. Dr. H. Pichler), University of Vienna, Vienna, Austria.* Experimented for years with root canals in infected teeth of dogs without any good results. Particularly wanted to know what would happen to dead cementum surface, which has no connection with living tissues, and to the main and accessory canals, especially the latter, which also have no vital connection with surrounding tissue.

In 2 apices of dogs' teeth which were infected 2½ months before commencement of treatment and examined 5½ months after root canal filling are found answers to these questions. Animals were killed at this time and sections made of the teeth and adjacent structures. In successful results as these 2, the old cementum with empty lacunae is covered with new cementum with cells in lacunae; drilled defect in canal is partly filled with new living cementum; entrance to accessory canal is closed by living cementum and deposit of cementum within its lumen. This indicates what might be expected from satisfactory root canal treatment.

67. CATCHER SPLINT (*die greiferschiene*). *Richard Grohs, M.D., Dental Institute (Director, Prof. Dr. H. Pichler), University of Vienna, Vienna, Austria.* (No manuscript received for publication.)

68. DENTAL DISEASE AND THEIR RELATION TO MAXILLARY ANTRUM. *Otto Hofer, M.D., Director of Department of Dental and Maxillary Diseases, Allgemeine Poliklinik, Vienna, Austria.* Secondary diseases of antrum may result from inflammations and suppurations originating from dental system. Acute dental disease rarely invades mucous membrane of maxillary sinus; as a rule invasion begins in chronic dental process followed by resorption of bone between dental focus and antrum. Antrum suppuration is initiated by: injury of alveolar process by accident or extraction, penetration of foreign bodies or root fragments, infection or necrosis of injured tissue in mouth with subsequent invasion of antrum, osteitis, osteomyelitis of upper jaw in adults, necrosis or damage from external or internal toxic actions, and malignant neoplasms of bone. Hypertrophy of antral mucous membrane without suppuration may have its origin in dental system, *sinusitis maxillaris comitans* of Zange. Prevention of empyema of maxillary antrum is discussed from dental point of view.

69. IONTOPHORETIC AND ELECTROLYTIC EXPERIMENTS. *Ernst Kellner, M.D., Dental Institute (Director, Prof. H. Pichler), University of Vienna, Vienna, Austria.* Electrolysis is limited to immediate neighborhood of electrode and is only suited for sterilizing that part of the root canal that has been exposed mechanically, Iontophoresis is a method for bringing ions into regions which cannot be reached mechanically or by diffusion, especially for canals which are not entirely passable. Conclusions are based on many hundreds of exami-

nations of iontophoresis using models, extracted teeth and experimental animals. Efficacy of anions and cations of solutions is absolutely independent of efficacy of solution itself. Strong disinfectants as bichloride of mercury are absolutely ineffective for most part. Speed of transport depends on potential gradient of the current. Metals are not well suited for iontophoresis; zinc in Appleton's solution is an exception. Effect of medicament is different for different bacteria; streptococci are not so easily influenced as staphylococci and mixed infections. The effects of various medicaments are discussed in some detail. It was possible to produce a compound which has better effect than the zinc-iodide-iodine solution having the formula, $K_2(HgI_4)$ or one having the formula, $Zn(HgI_4)$, in which free iodine is brought to absorption.

70. UNUSUAL PROCESS OF HEALING AFTER APICOTOMY. *E. Kolanyi, M.D., Dental Institute (Director, Prof. Dr. H. Pichler), University of Vienna, Vienna, Austria.* Six years ago an apicoectomy was performed under local anesthesia on lower right first premolar for a patient about 30 years of age. Healing did not occur by first intention, resulting in exposure of root stump. Surface of root stump was treated by use of 30 per cent solution of silver nitrate precipitated with hydroquinone solution. This treatment was repeated approximately 8 times, after which patient failed to return. When the patient brought her husband in for treament $5\frac{1}{2}$ years later she was examined and, suprisingly, normal healing was found except for evidence of increased vascularity of mucous membrane. Result was unusual since in very few cases of this type could normal healing have occurred. Usual result would be most unsatisfactory.

71. NEW STEP IN TECHNIQUE OF INJECTION OF ALCOHOL INTO GASSERIAN GANGLION. *H. Pichler, M.D., Director Dental Institute, University of Vienna, Vienna, Austria.* By successful injection of alcohol for trifacial neuralgia, ganglion cells of the Gasserian ganglion may be entirely destroyed just as by total extirpation. Injected alcohol does not always diffuse evenly within nervous tissue, sensibility of 1 or 2 branches may be destroyed by first few drops and that of another branch or part of it is not influenced by injecting more alcohol. Injection of additional fluid from same site is likely to cause complications

by spread of fluid outside of ganglion. Formerly this was handled by withdrawing needle and reinserting it in new position within foramen. A much more successful method in our hands in such cases is insertion of 2 or more cannulas in foramin ovale, one beside the other, so as to deposit the alcohol in different location in the ganglion. First cannula acts as guide for succeeding ones. Generally speaking it is possible to achieve success in this way at 1 sitting. However, incomplete injection is never to be considered satisfactory, and should be repeated within next few weeks before scar tissue can develop.

72. SURGICAL TREATMENT OF DEEP GINGIVAL POCKETS. *Franz Schönbauer, M.D., Dental Institute, (Director, Prof. Dr. H. Pichler), University of Vienna, Vienna, Austria.* (No manuscript received for publication.)

73. CONTRIBUTION TO PROBLEM OF DENTAL CARIES. *Georg Stein, M.D., Dental Institute (Director, Prof. Dr. H. Pichler), University of Vienna, Vienna, Austria.* Condition of hard tissues of teeth (hypoplasia) is considered minor cause for development of caries. Studies of deciduous teeth indicate that disturbances of metabolism at time of development of teeth influence quality of enamel so that these teeth have greater inclination to caries in parts formed at time of disturbance of calcium metabolism. This opinion is further supported by study of 2 fraternal twins, boy and girl living under identically the same conditions, weight at birth 5 pounds. Both children showed some susceptibility to caries but in case of boy there is noticeable circular caries in developmental lines, especially on labial incisor surfaces; this condition is entirely absent in girl. At age of 2 months the boy had a severe intestinal catarrh of 3 months duration and lost much weight. The girl was absolutely healthy during this period. This observation seems to confirm opinion that quality of dental substance plays some part in origin of caries.

74. INCOMPLETE FUSION OF ORAL EPITHELIUM AND UNITED ENAMEL EPITHELIUM OF RAT MOLAR. *Josef Weinmann, M.D., Dental Institute (Director, Prof. Dr. H. Pichler), University of Vienna, Vienna, Austria.* In humans following eruption of teeth, fusion between oral epithelium and united enamel epithelium is so firm that it is impossible to differentiate between them in epithelial attachment. In contrast, both of these parts of epithelium of epithelial attachment of rats' molars

are separated. Mouth epithelium grows a short distance behind enamel epithelium and retains its ability to hornify. Adjacent to enamel is a relatively broad layer of epithelium without hornification, enamel organ portion of attachment. Outside of this is layer of mouth epithelium, of more solid consistency with hornified layer between all or part of it and enamel organ portion.

C. CONTRIBUTIONS BY OTHER MEMBERS OF THE ASSOCIATION, AND BY GUESTS, WHO COULD NOT BE PRESENT: ABSTRACTS 75–112

75. SACCHARIFICATION STUDIES OF PTYALIN. *Frank Allen, D.D.S., and Virgil Cheyne, D.D.S., Medical-Dental School, University of Rochester, Rochester, N. Y.* (No manuscript received for publication.)

76. GRENZ RAY STUDIES OF CALCIFICATION OF ENAMEL. *Edmund Applebaum, D.D.S., Dental School, Columbia University, New York, N. Y.* Attempt made to clarify mechanism of enamel formation by soft-x-ray studies. Enamel apposed in incremental layers and calcifies through different stages en masse. One stage radiolucent and acid insoluble (primary, young and transitional of von Ebner). (Published in *J. D. Res.* **17:** 181, 1938.)

77. DECALCIFICATION VS. MECHANICAL INJURY. *Edmund Applebaum, D.D.S., and T. H. Adam, A.B., Dental School, Columbia University, New York, N. Y.* Presence of crack or lamellae-like structures in rat enamel without caries seems to invalidate idea they initiate caries. Grenz ray reveals decalcification in incipient caries, in addition to crack or lamella, supporting Miller's theory. With decalcification alone extensive tooth destruction may take place without mechanical aid. Mechanical factor may play secondary râle in removing decalcified debris. (Published in *J. D. Res.* **17:** 95, 1938.)

78. HUMAN SALIVA, V: FUNDAMENTAL PRINCIPLES OF PHOSPHORUS ANALYSIS AND THEIR APPLICATION TO FRACTIONAL DETERMINATION IN SALIVA. *Hermann Becks, M.D., D.M.D., D.D.S., F.A.C.D., and W. W. Wainwright, D.D.S., M.S., George Williams Hooper Foundation for Medical Research and Dental School, University of California, San Francisco, Cal.* (No manuscript received for publication.)

79. HUMAN SALIVA, VI: EFFECT OF ACTIVATION ON SALIVARY FLOW. *Hermann Becks, M.D., D.M.D., D.D.S., F.A.C.D., George Williams Hooper Foundation for Medical Research and Dental School, Univer-*

*sity of California, San Francisco, Cal.* (No manuscript received for publication.)

80. HUMAN SALIVA, VII: EFFECT OF ACTIVATION UPON CALCIUM AND INORGANIC PHOSPHORUS COMPOSITION. *Herman Becks, M.D., D.M.D., D.D.S., F.A.C.D., George Williams Hooper Foundation for Medical Research and Dental School, University of California, San Francisco, Cal.* (No manuscript received for publication.)

81. EAR DISTURBANCE OF TEMPORO-MANDIBULAR ORIGIN. *Ross F. Bleiker, A.B., D.D.S., Dental School, St. Louis University, St. Louis, Mo.* (1) Several dissections made of temporo-mandibular region. Anterior tympanic artery and chorda tympani nerve pass in closest relation to condyle head when entering petrotympanic fissure on way to middle ear. Since artery and nerve pass through petrotympanic fissure, artery supplying anterior two-thirds of tympanic membrane, and nerve passing between malleus and incus, any pressure produced by head of condyle on artery and nerve would create ear disturbance. (2) To treat cause of ear disturbances of above nature, it is necessary to show exact position of heads of condyles in relation to petrotympanic fissures. (This is accomplished, in cases tested, by means of laminagraph records, made by Dr. Sherwood Moore, Mallinckrodt Institute of Radiology, Washington University, St. Louis, Mo.) (3) Possible cause of failure in correcting ear disturbances of dental origin is that bite may be opened and yet not bring condyles forward. (4) All temporo-mandibular joints are different and vary in individual cases. Every case studied thus far confirmed by laminagraph. Excursion of condyles demonstrated by placing bite blocks of different heights between mandible and maxilla under consideration. (5) Center of fulcrum is mid-ramus of mandible under consideration. (6) Width of mandibles enters into changing of center of fulcrum. Seventy-eight mandibles measured and widths recorded: (a) Narrow, 2.5 to 3.0 cm; medium, 3.5 cm; wide, 4.0 to 4.7 cm. (7) Of clinical cases treated, one with definite ear disturbance, slight improvement in hearing was reported by patient after balancing occlusion and definitely showing head of condyle anterior to fissure. (Published in *J.A.D.A.* **25**: 1390, 1938.)

82. DENTAL CARIES IN GUINEA PIG. *P. E. Boyle, D.M.D., and O. A. Bessey, Ph.D., Dental and Medical Schools, Harvard University,*

*Boston, Mass.* Dental caries found in constantly growing incisor and/or molar teeth of 38 guinea pigs of 100 animals examined. Caries appears in part of tooth exposed to oral fluids, usually involving exposed dentin on surfaces of teeth worn off in mastication although occasionally involving cementum covered surfaces. Histological examination was made of decalcified specimens. In most instances only 1 to 2 sections passed through areas usually found to be carious. Figures given, therefore, are a minimum value of caries index. Process appears identical with caries of dentin of human teeth. Enlargement of dentinal tubules, presence of microörganisms within tubules, and eventually focal disintegration of dentin, found histologically. Carious process does not appear to be associated with defective tooth structure nor with complete or partial dietary deficiencies of either vitamin A or vitamin C. Forty-one percent of animals (7 of 17) on diet adequate in all known respects, including liberal amounts of fresh green vegetables, in which tooth structure appeared entirely normal, showed caries of dentin.

83. BUCKY-GRENZ RAY IN TREATMENT OF (A) ORAL TUBERCULOUS LESIONS AND (B) PERIODONTOCLASIA. *Ralph Howard Brodsky, D.M.D. and Gustave Bucky, M.D., Sea View Hospital, Staten Island, N. Y.* (No manuscript received for publication.)

84. BACTERIOLOGIC STUDIES OF DIFFERENT AREAS OF TEETH AND THEIR SUPPORTING STRUCTURES. *Lester W. Burket, D.D.S., Dental School, University of Pennsylvania, Philadelphia, Pa.* (No manuscript received for publication.)

85. TEST OF EFFECT OF DIFFERENT GROWTH RATES ON TRANSVERSE PRISM-STRIPES. *S. W. Chase, A.M., Ph.D., Dental School, Western Reserve University, Cleveland, Ohio.* (No manuscript received for publication.)

86. ORAL MANIFESTATIONS IN HEMORRHAGICA PURPURA. *Thomas J. Cook, D.D.S., Dental School, University of Pennsylvania, Philadelphia, Pa.* (No manuscript received for publication.)

87. PLASTICITY OF CALCIFIED TISSUES: III. EFFECTS OF DIETS HIGH IN PROTEINS, FATS, AND CARBOHYDRATES, RESPECTIVELY ON TEETH AND JAWS OF ALBINO RATS; IV. EFFECTS OF MARKED VARIATIONS IN CALCIUM OR PHOSPHORUS CONTENT OF DIET ON TEETH AND BONES OF ALBINO RATS. *William G. Downs, Jr., D.D.S., A.M., Ph.D., and*

*Raymond McKeown, A.M., M.D., Medical School, Yale University, New Haven, Conn.* (No manuscript received for publication.)

88. STUDY BY AGE AND SEX OF INCIDENCE OF DENTAL CARIES IN OVER 12,000 PERSONS. *Franklin Hollander, Ph.D., Dental School, Columbia University, and James M. Dunning, D.D.S., Dental Division Metropolitan Life Insurance Co., New York, N. Y.* Continuation of Hyatt's studies (*J. D. Res.*, **9:** 411, 1928) yields following: (1) Initiation of new carious lesions continues past childhood and adolescence at least until middle life at slowly and progressively decreasing rate, decrease being more marked from 25 to 35 years than during any like period. (2) Throughout almost entire age range caries incidence is significantly higher among women than among men, especially above age 34. (3) Statistical results from this group are essentially different from those obtained from groups of similar social and economic status studied at time of dental treatment. The former is preferable for statistical purposes. (4) For large scale estimation of caries incidence in whole mouth, analyses in terms of decayed surfaces and of decayed teeth per person yield essentially similar results, but former criterion is more sensitive. (5) Further work must give particular attention to:—(a) statistical re-evaluation of factor 3 used in converting number of missing or crowned teeth into carious surfaces, including determination of teeth lost because of periodontoclasis; (b) extension in age range down to age 6 and from 50 upward; (c) break down of caries process into its different elements according to types of decay and surfaces involved; (d) effect of child-birth upon caries incidence; (e) computation of caries incidence in terms of morbidity rate.

89. POSSIBLE CAUSE OF INTERNAL POROSITY IN VULCANITE. *Vitorien Dubé, A.B., B.C.D., D.D.S., M.S.D., and E. W. Skinner, Ph.D., Dental School, Northwestern University, Chicago, Ill.* Various properties of vulcanite studied by vulcanizing ½ inch cubes packed in usual manner at various temperatures for 2 hours. Specific gravity remained constant at approximately 1.25 from 70 pounds gauge pressure (150°C.) to 100 pounds (164° C.) after which internal porosity occurred, and sudden decrease in apparent density was evidenced. Above 100 pounds, area of porosity increased with increase in temperature until evidence of molecular disintegration was found. Volume

shrinkage increased from −8.3 percent at 70 pounds, to −9.1 percent at 90 pounds. It then decreased to −8.8 percent at 100 pounds, and changed to an expansion as porosity developed. Surface hardness and flow were independent of internal conditions. It may be assumed therefore that porosity is an internal condition caused by substitution reaction between sulfur and rubber, which occurs above critical temperature of vulcanization—in this case above 164°C.

90. AMELOBLASTOMA ASSOCIATED WITH DENTIGEROUS CYST. *F. A. Figi, M.D., F.A.C.S., and E. C. Stafne, D.D.S., Sections on Laryngology and Dental Surgery, Mayo Clinic, Rochester, Minn.* Tumor 4 x 4.5 x 5 cm. removed from right maxillary region almost completely replacing the maxillary sinus, in girl 16 years of age. Histologic diagnosis was dentigerous cyst. Wall of cyst measured in some places 1 cm. in thickness. Part of cystic cavity was occupied by crown of canine tooth from which growth originated. Remaining space was filled with firm granular tissue; histological examination of this tissue revealed it to be an ameloblastoma. No ameloblastoma tissues were found in study of several sections of cystic wall. This type of tumor is in many respects similar to those which have been reported by Cahn, Churchill, Thoma, Proctor, and others.

91. FACTORS IN UNSTIMULATED SALIVA CORRELATED WITH PRESENCE AND ACTIVITY OF DENTAL CARIES. *Maxwell Karshan, Ph.D., Medical and Dental Schools, Columbia University, New York, N. Y.* Unstimulated saliva of persons with and without dental caries analyzed for $CO_2$ capacity, total Ca, inorganic P, and protein; fractions of Ca, P, and protein removed from saliva on shaking with commercial tricalcium phosphate. Since commercial tricalcium phosphate is not uniform in composition, single sample, same as in previous study on stimulated saliva (*J. D. Res.*, **15:** 383, 1936), used. Preparations, acting on saliva like the tricalcium phosphate used in these studies, have been prepared by author from phosphoric acid and calcium carbonate. Saliva collected in 2 portions, approximately 15 minutes apart, 1–3 hours after breakfast. First portion (15 cc.) used for determination of Ca, P, and protein; second portion (8 cc.) for $CO_2$ capacity. To remove fractions of Ca, P and protein, 5 grams of tricalcium phosphate were added to 10 cc. of saliva; mixture, in glass-stoppered bottle, shaken mechanically for 2 hours, centrifuged, and supernatant fluid an-

alyzed. Saliva of caries-free and arrested-caries groups differed in several characteristics from that of active caries group as shown in table.

| | NO. OF CASES | TOTAL Ca | INORGANIC P | CALCIUM REMOVED | PHOSPHORUS REMOVED | $CO_2$ CAPACITY CC. PER 100 CC. | PROTEIN | |
|---|---|---|---|---|---|---|---|---|
| | | Mg./100 cc. | | Percent | | | Mg. per 100 cc. | Percent Removed |
| Caries—free* | 21 | 6.5 | 18.5 | 54 | 63 | 13.4 | 313 | 57 |
| Arrested caries | 13 | 6.4 | 18.5 | 50 | 60 | 12.9 | 330 | 55 |
| Active caries | 25 | 5.7 | 14.6 | 26 | 67 | 9.5 | 335 | 59 |

* Average age approx. same in 3 groups (range 10–29)

92. STUDY OF VARIOUS METHODS TO CONTROL DIMENSIONAL FIT OF GOLD CASTINGS. *Max Kornfeld, D.D.S., Dental School, St. Louis University, St. Louis, Mo.* Method of Scheu, using his hygroscopic investment, was studied. With 150 grams of powder and water ratio of 32/100, specimen was spatulated for 1 minute, allowed to stand for 10 minutes including time of spatulation before immersion in water bath. Other specimens allowed to stand for 15 minutes, 17½ minutes, etc. Finally specimens were retained in water bath from 5 to 30 minutes before determining setting expansion. Setting expansions from .244 per cent to .826 per cent were obtained. Scheu's technic is considered to be one of real significance from scientific standpoint but of little real value in hands of students and practitioners because of difficulties and variables involved.

93. SALIVARY PROTEIN. *Frances Krasnow, Ph.D., and Edith B. Oblatt, A.B., Guggenheim Dental Clinic, New York, N. Y.* Evaluation of data on 150 cases ranging in age from 5 to 50 years. Series includes individuals who are (1) without any malfunction as far as medico-dental clinical and laboratory examination could discern, (2) caries free but have systemic involvement, (3) caries susceptible without or with other ailments not specifically dental in nature, (4) suffering from erosion (abrasion, wastings) without or with additional pathology. There is apparently a statistically significant elevation for groups (2), (3), and (4), when respective averages are compared with that of group (1). Odds against random occurrence of differences

seem to increase as the care in selecting "normals" becomes more scrupulous. Also, analytical method developed for determination of total salivary protein is critically compared with other available procedures and shown to be accurately applicable.

94. ROENTGENOGRAPHIC COMPARISON OF BONE AND DENTAL AGE WITH CHRONOLOGICAL AGE. *Paul K. Losch, D.D.S., Earle C. Cummings, D.M.D., and Fred W. Morse, Jr., M.D., Dental School, Harvard University, Boston, Mass.* Employing Todd's Atlas of Hand and chronological table of tooth development previously devised in this clinic as standards, roentgenographic comparison of skeletal and dental development with chronological age was made. Selection of cases for comparative assessment based on those roentgenograms of hand which were readily interpreted within Todd standards. Progressive development of deciduous canine and molars and permanent canine, pre-molars and molars was made from roentgenograms of single lateral jaw exposure. All factors of position and exposure were constant. Age levels ranged from 2½ years to 14½ years. Since selection was based on Todd standards, skeletal age in all cases was found consistently in accord with chronological age of both sexes. Assessment of dental age, compared to chronological age was sufficiently constant in both male and female that a division of standards by sexes for dental development does not seem warranted as it is in skeletal development. In a few cases where a plus or minus deviation from the standard in dental development was noted margin of deviation was constant over progressive age levels.

95. STUDIES ON DENTAL CARIES. III. MEASUREMENT OF POST ERUPTIVE TOOTH AGE. *Carroll E. Palmer, M.D., Henry Klein, D.D.S., and Morton Kramer, D.D.S., National Institute of Health, United States Public Health Service, Washington, D. C.* In recent publication (*Growth*, **1**: 385, 1938) the authors have shown that simple mathematical equation, normal probability function, may be used to describe eruption of permanent teeth in the human mouth. It was also shown in this report that this fact is of considerable importance in the quantitative approach to a variety of problems related to growth and development and dental disease. Use of this precise method for describing eruption of teeth facilitates measurement of length of time teeth are exposed to risk of attack by dental caries (post eruptive

tooth age). Post-eruptive tooth years of mouth exposure is calculated from the double integral of the normal curve which describes eruption of teeth.

96. FACIAL AND DENTAL ARCH FORM OF ANCIENT PERUVIANS. *Weston A. Price, D.D.S., M.S., F.A.C.D., Dental Research Laboratories, Cleveland, Ohio.* Influence of Humboldt current and its abundance of sea foods on ancient cultures as expressed in skeletal material studied in Peru. Ancient method of preparation and burial in dry desert sand of coastal area has preserved skeletons in excellent physical condition. Examination of over 1200 skulls to note facial form, size and shape of dental arches did not disclose a single arch with even moderate malformation such as is typical of large percentage of individuals in our modern civilizations. Diet of these cultures is indicated by foods that were interred with bodies, equipment used to secure foods and reproduction of food in pottery forms. Their foods included various animal life from the sea and variety of cereals, root plants, greens and vegetables raised by irrigation in river valleys.

97. COMPARISON OF FACIAL AND DENTAL ARCH FORMS IN PRIMITIVE AND MODERNIZED PERUVIAN INDIANS. *Weston A. Price, D.D.S., M.S., F.A.C.D., Dental Research Laboratories, Cleveland, Ohio.* Studies made of native Indians in Peru, some of whom were reported as descendants of ancient civilizations, and living in isolated villages on sea coast. Some were in process of recent modernization due to establishment of plantations. All older individuals in these groups had splendidly formed dental arches and normal tribal facial design, whereas in some of these communities which were being modernized, many of their children had badly deformed dental arches with narrow faces. Imported foods used included white flour, sugar, vegetable fats and canned goods used liberally in homes of native workman employed on plantations. Similar studies were made of native Indian tribes in high Sierras of the Andes. Where they were living on native foods, facial and dental arch form of both parents and children were excellent and reproduced tribal pattern. Where modern imported foods have been introduced and used by parents, there was marked narrowing of face with deformity of dental arches. Dietary program of these natives was very different from that of past and present coastal Indians and consisted largely of plant products. Some animal foods

were used regularly. Similar studies were made of 2 Indian tribes in Amazon basin which provided an entirely different type of food and living conditions from either of former groups. Dental arches of individuals of all ages were excellent. Native nutrition included abundant plant and animal foods, such as fresh water fish and roots of yuca plant.

98. STUDY OF PULP PATHOLOGY OF TEETH WITH CLINICAL HISTORIES. *Leslie F. Rittershofer, D.D.S., M.S., Dental School, University of Michigan, Ann Arbor, Mich.* Primary purpose of study of over 100 teeth, is to correlate microscopic pathologic changes with clinical histories and clinical tests of pulps studied. Material shows considerable amounts of chronic inflammatory processes. Pulp nodules were found in pulps otherwise normal. Generally, extreme sensitivity to heat and cold found in pulps with acute inflammation although pulp stroma was more or less intact. Sensitivity to cold decreased as pulp stroma progressively broken down. Small number of specimens, so-called borderline cases, those with but little or no clinical signs or symptoms extremely interesting from diagnostic point of view. Specimens in this group showed in some cases advanced congestion, and very active inflammation; in others chronic changes or atrophy; pulp stroma was markedly altered if not completely broken down. Such pulps were found: (1) in teeth with active deep seated caries, without pulp exposure; (2) in teeth subjected to severe trauma, and no caries; (3) in teeth with deep and large metal fillings; (4) in teeth with history of long continued sensitivity to heat and cold; and (5) in teeth where deposition of secondary dentine may have reduced canal lumen at apex.

99. RESEARCH ON FLOW OF DENTAL AMALGAMS. *Eugene W. Skinner, Ph.D., Dental School, Northwestern University, Chicago, Ill.* Flow curves obtained by standard amalgam flow testing apparatus at 37°C. show first, a tendency to be exponential with time, but later they become linear with time. When specimens are tested 3 hours after trituration, exponential portion is probably due to (1) hardening of amalgam and (2) inhomogeneities incurred during condensation. After these effects become neutralized, flow is linear with time. It is proposed that *total flow*, as ordinarily measured, be differentiated from *constant flow*, which is given by slope of straight line portion, and is

more indicative of true flow properties since it is more nearly independent of hardening rate. Data presented to show that flow decreases with increase in condensation pressure, but never reaches zero, although pressures were used greatly in excess of those in dental practice. Trituration time within normal limits has little effect upon flow. It was shown that as amalgam ages, flow decreases, but never reaches zero. Aging process is very slow; an accelerated aging at 60°C. required 3 months time before flow reached constant value upon further aging.

100. AUTOMATIC RECORDER FOR MEASUREMENT OF AMALGAM FLOW. *Eugene W. Skinner, Dental School, Northwestern University, Chicago, Ill.* Apparatus designed to photograph automatically dial micrometer on flow tester, together with clock, in order to obtain continuous readings. Timing switch, operated by electric clock, turns on two 500 watt lamps, energizes electromagnet which operates shutter of Leica camera (f3.5), shuts off lights, and finaly energizes a solenoid which winds camera film. By means of relay attached to master clock which is photographed, apparatus may be regulated to take picture over consecutive periods ranging from 30 minutes to 12 hours.

101. INTERNAL RESORPTION OF DENTIN IN A VITAL TOOTH. *W. F. Swanson, M.S., D.D.S., F.A.C.D., L. E. Van Kirk, M.S., D.D.S., F.A.C.D., and F. M. Holstein, D.D.S., Dental School, University of Pittsburgh, Pittsburgh, Pa.* (No manuscript received for publication.)

102. COMPARISON OF TEST TUBE AND QUANTITATIVE PLATE METHODS FOR ESTIMATION OF LACTOBACILLI IN SALIVA. *Marshall L. Snyder, Ph.D., Hygienic Laboratory, University of Michigan, Ann Arbor, Mich.* After determining quantitative plating technique employed by Hadley, Hay, Bunting et al. to be satisfactory for estimation of lactobacilli in saliva, attempt was made to devise test tube method to supplement plate and microscopic work. Hoped to show that within limits production of acid was function of time and number of lactobacilli in saliva. Medium used—glucose infusion agar adjucted to pH 5.0 with brompresol as indicator; inoculation made with 0.1 – 0.3 cc. quantities of saliva, and color changes which ranged from blue-green of controls and negative tests to yellow of completely changed medium were recorded every 12–24 hours for 96 hours. A total of 725 salivas were tested, and color changes compared with respective plate counts

made independently by Jay. Of these, 289 specimens were negative or contained less than 100 lactobacilli per cc. of saliva. Significant color changes were observed in only 5, or 2.0%, of these cases in 48 hours. So far, however, it has not been possible, with salivas containing more than 1,000 lactobacilli per cc. of saliva, to differentiate accurately between high and low counts with this method.

103. SOME OBSERVATIONS ON POROSITY OF VULCANITE. *P. B. Taylor, A.M., Dental School, Western Reserve University, Cleveland, Ohio.* (No manuscript received for publication.)

104. FACTORS IN UNSTIMULATED SALIVA CORRELATED WITH CALCULUS. *Benjamin Tenenbaum, B.S., D.D.S., and Maxwell Karshan, Ph.D., Medical and Dental Schools, Columbia University, New York, N. Y.* Unstimulated saliva of persons with and without calculus analyzed for total Ca, inorganic P, pH and protein. Saliva collected in 3 successive portions, 1–3 hours after breakfast. First portion (1 cc.) collected under paraffin oil, used for initial pH; second portion (5–6 cc.) used for Ca, P, protein; third portion (1 cc.), collected under oil, used for final pH determinations. Of 46 persons, 20–60 years old, 14 were calculus free and had not had dental prophylaxis for at least 1 year. Remainder had varying degrees of deposits. Mean values for Ca and P in calculus-free group lower than in calculus group; 5.6 mg. percent Ca and 16.8 mg. percent P in former as compared with 6.5 mg. per cent Ca and 19.2 per cent P in latter group. Much smaller differences in mean values found between 2 groups in pH and protein. Calculus free group: initial pH 6.75, final pH 6.86, protein 306 mg. percent. Calculus group: initial pH 6.80, final pH 6.88, protein 320 mg. percent. Differences in mean values between calculus-free and calculus groups in Ca, inorganic P, pH and protein of stimulated saliva were previously reported by authors (*J. A. D. A.* **24:** 1255, 1937).

105. RELATIVE EFFECT OF DIET UPON BODY WEIGHT, SKELETAL DEVELOPMENT AND RATE OF ERUPTION OF INCISOR TEETH OF ALBINO RATS. *Margaret Cammack Smith, A.B., A.M., Ph.D., and Emily Gillam, B.S., M.S., University of Arizona, Tucson, Arizona.* (No manuscript received for publication.)

106. OSTEOGENIC TUMORS. *Kurt H. Thoma, D.M.D., Dental School, Harvard University, Boston, Mass.* (No manuscript received for publication.)

107. HEAT TREATMENT OF SOLDERED ORTHODONTIC JOINTS. *W. J. Turbyfill, D.D.S., M.S.D., and Eugene W. Skinner, Ph.D., Dental School, Northwestern University, Chicago, Ill.* Three different types of orthodontic wires tested for ultimate tensile strength and Brinell hardness under different conditions of heat treatment up to soldering temperature (1650°F.); type I, high in platinum and palladium; type II, usual type type, III, contained only platinum, palladium, and silver. Type I showed peculiar property of requiring temperature in excess of 1400°F. for softening after soldering. Type III was not amenable to hardening heat treatment. Two solders, 650 fine and 490 fine respectively, tested in similar manner. Soldered joints constructed with various wires and solders were tested for ultimate tensile strength under different conditions of heat treatment. In air-cooled and softened conditions, 490-fine joints were stronger than 650-fine; but when "over-cooled", strengths of joints appeared to be independent of fineness of solder. With type III wire, only joints with 650-fine solder responded to heat treatment. All joints fractured in solder, and exhibited strength greater than that of solder alone, but less than that of respective wire, regardless of heat treatment. This may be accounted for by assuming that atomic diffusion took place between wire and solder, as well as between solder and wire.

108. A METHOD FOR DETERMINING BLOOD CLOTTING TIME. *J. F. Volker, Medical-Dental School, University of Rochester, Rochester, N. Y.* Apparatus for duplicated blood clotting determinations described. Clotting time estimations are based on movement of solid spheres in sealed test tubes. Method gives accurate estimations of relative coagulating ability of blood samples. Duplicate measurements check within 3 seconds. Method was designed to test action of salivary extracts and concentrates on clotting time of blood.

109. HUMAN SALIVA, VIII: METHODS OF BIOMETRICAL EVALUATION OF SALIVARY ANALYSES. *W. W. Wainwright, D.D.S., M.S., George Williams Hooper Foundation for Medical Research and Dental School, University of California, San Francisco, Cal.* (No manuscript received for publication.)

110. TABULATION OF DATA ON MONTHLY FOOD SUPPLY AND INCIDENCE OF DENTAL CARIES IN PRIMITIVE ALASKANS. *L. M. Waugh,*

*D.D.S., F.A.C.D., Dental School, Columbia University, New York, N. Y.* (No manuscript received for publication.)

111. REPORT OF STUDIES BEING MADE ON PULP PATHOLOGY WITH SPECIAL REFERENCE TO ETIOLOGY. *Harold G. Worman, D.D.S., Dental School, University of Minnesota, Minneapolis, Minn.* (No manuscript received for publication.)

112. LABORATORY AND CLINICAL STUDIES OF ORAL OSTEOSCLEROSIS. *James L. Zemsky, D.D.S., F.I.C.A., Dental School, Columbia University, New York, N. Y.* (No manuscript received for publication.)

## XII. NECROLOGY*

*T. B. Beust*, p. 336; *A. D. Black*, p. 337; *C. L. Drain*, p. 338; *J. Szabo*, p. 339.

### THEODORE BERNHARD BEUST: 1871–1937

Dr. Theodore Bernhard Beust died on November 24, 1937. He was born in New Albany, Indiana, in 1871. After completing his high school course in New Albany, he attended the Louisville College of Dentistry, graduated, and later obtained a medical degree from the Hospital College of Medicine in Louisville. Dr. Beust practised dentistry in New Albany from 1892 until 1897 when he moved to Dresden, Germany. There he established his own private research laboratory and his first publications on scientific subjects began in 1905. Fifteen articles, mostly of oral bacteriological studies, were published during his stay at Dresden. The second year of the World War caused conditions in Germany which made it necessary for Dr. Beust and his family to return to the United States, leaving practically everything that they owned behind them.

Dr. Beust returned to the University of Louisville College of Dentistry and began work first as Professor of Bacteriology and Biology and later as Professor of Dental Histology, Comparative Anatomy. He continued in this position until his death. An Award of Merit was bestowed upon Dr. Beust by the faculty of the University of Louisville in recognition of his ability and in view of the fact that he

* Third annual report of the Necrology Committee, Frederick B. Noyes, chairman. The report for 1937 was published in J. Den. Res., 16: 356, 1937; for 1936, Idem, 15: 374, 1936.

had contributed more to the advancement of science and research than any other member of its faculty. Dr. Beust was elected to the Presidency of the International Association for Dental Research for the year 1935–36. He was a Fellow of the American College of Dentists and a member of Omicron Kappa Upsilon.

The publications of Dr. Beust which were of greatest fundamental importance may be grouped under the following heads: (1) work on the morphology of the oral organisms, (2) resistance to caries, (3) the anatomical arrangement of enamel tufts and their alignment into vertical rows and (4) the establishment of the idea of tooth maturation and the occurrence and significance of dentin sclerosis. In all, there were over 50 contributions to the scientific literature of dentistry, an enduring monument to him whose own words regarding personal achievement were, "If any achievements are obvious, then well and good."

## ARTHUR DAVENPORT BLACK: 1870–1937

Dr. Black died on December 7, 1937 at the age of sixty-seven. He was the son of Dr. Greene Vardiman and Elizabeth (Davenport) Black. He received his academic education at Illinois College in Jacksonville, Illinois, his birthplace, graduating in 1892. Subsequently he obtained the dental and medical degrees from the Schools of Dentistry and Medicine, Northwestern University in 1900 and 1901.

Following his graduation in dentistry, Dr. Black took the position of Quizmaster at the Northwestern University Dental School. He served in the positions of Demonstrator, Assistant Professor and Professor of Operative Dentistry and assistant in Oral Surgery, Assistant Dean and Professor of Dental Pathology and Operative Dentistry, and as Junior Dean. In 1918 he was made Dean although he still retained the position of Professor of Dental Pathology and Operative Dentistry. During this same year Dr. Black received the honorary degree of Sc.D. from Illinois College.

Dr. Black served as President of the International Association for Dental Research in 1929–30 and in 1933 he served as President of the Chicago Centennial Dental Congress. In 1937 the Alumni Medal Award was conferred upon him by Northwestern University.

While still in dental school, Dr. Black became interested in the classification and indexing of dental literature. He worked out the dental classification with the Dewey Decimal System and began the work of indexing periodicals of dental literature in the English language. This is one of his greatest contributions to the profession. It has been a sustained effort over many years.

Dr. Black has been active and influential in almost all dental organizations, especially the American Association of Dental Schools, Omicron Kappa Upsilon, Delta Sigma Delta, and in every institution undertaking constructive work for the profession. At the time of his death Dr. Black was serving as a trustee of the Endowment Fund of the International Association for Dental Research.

## CHARLES LAWRENCE DRAIN: 1895–1937

Dr. Charles Lawrence Drain died on June 5, 1937. He was born at Missouri Valley, Iowa, on February 7, 1895. He was graduated from the Missouri Valley High School and enrolled in the College of Dentistry of the University of Iowa, graduating from there on June 13, 1917. From 1917 until 1919 he served as first lieutenant in the dental corps of the army. Upon his return to civilian life he established a dental practice in Des Moines, Iowa. In 1920 he was appointed Lecturer and Instructor in Pedodontia in the State University of Iowa, College of Dentistry, earning promotions until he was made Professor in 1936.

In addition to his teaching activities he was actively engaged in research on problems in dental caries, collaborating with Doctors Jeans and Boyd of the Department of Pediatrics in the University of Iowa College of Medicine. The work of this group has been an important contribution to scientific research.

Dr. Drain was Director of the Bureau of Dental Hygiene at the time of his death, being responsible over the past years for much of the success of this educational program in Iowa. He was the author of many published articles on dental caries and preventive dentistry.

Dr. Drain was a member of the American Dental Association, Iowa State Dental Society, International Association for Dental Research, and the American College of Dentists as well as of Omicron Kappa Upsilon. He was a member of the Boards of Directors of the Good

Teeth Council for Children and the American Society for the Promotion of Dentistry for Children.

Dr. Drain was fatally injured in an automobile accident on June 5, just a few hours after attending a reunion of his dental class held in connection with the commencement exercises of the university.

### JOZSEF SZABO: 1874–1937

Dr. Jozsef Szabo of VIII. Maria Ucca 52, Budapest, Hungary, died on May 17, 1937 at the age of sixty-three. He had been Director of the Dental Institute of the University of Budapest since 1919. He started in dentistry about 1898. In 1902 he began his work on the action of silver nitrate on the pulp and dentin and in 1913 prepared a textbook on dentistry which is considered to be the best textbook in the Hungarian language. Several new editions of the book were published from time to time. In 1936 Dr. Szabo published a book on Oral Surgery. Numerous articles by Szabo have been published in Hungarian, Austrian, German and Italian journals.

## XIII. Executive Proceedings

### A. REPORTS OF OFFICERS AND COMMITTEES

Council learned informally of prospective invitation to Association to coöperate with American College of Dentists in furtherance of dental research through grants for fellowships and for annual awards in recognition of achievement in dental research (as stated at annual dinner, for the College, by Dr. A. L. Midgley, p. 317). Council indicated its receptive attitude in a manner to warrant President Kitchin's appointment of standing "Committee on Coöperation with the American College of Dentists," to consist, for 1938–39, of Drs. T. J. Hill, chairman; A. W. Bryan and F. H. Cushman.

Proposal to increase annual dues to $5.00, to include a subscription for the *Journal of Dental Research* for each member, was rejected. But Council voted to indicate to all of sections its hope that each section will endeavor to show cause to all of its members why each should voluntarily subscribe for the J.D.R. at the $4.00 rate.

Discussion of desirability of including, *on the oral program*, papers on industrial research resulted in further allusions to need for restric-

tions to prevent overcrowding, and in reaffirmation of standing rule to exclude such papers unless, in judgment of Program Committee, special conditions warrant exceptions in individual instances.

During the past year there were two resignations of membership: Dr. Frederic N. Doubleday, Guy's Hospital, London, England (May 1937), and Dr. Clarence O. Simpson, University Club Bldg., St. Louis, Mo. (Dec. 1937). Resignations became automatically effective upon receipt by the General Secretary.

The following resolutions were presented (1–2):

"(1) *Resolved* that the International Association for Dental Research in Sixteenth General Meeting assembled in the City of Minneapolis, Minnesota, on March 13, 1938, desires to express its deep appreciation of the support given by the Office of Indian Affairs, United States Department of the Interior, to the Survey and Research among the Alaskan Eskimos into the problem of Dental Caries under the leadership of Dr. Leuman M. Waugh. Reports that he has regularly made to this body give evidence of important progress in the solution of the cause and cure of the disease. This will be a most important contribution to the health and welfare of the natives and whites everywhere. It is, therefore, respectfully urged that adequate facilities be provided in Government hospitals for the continuance of dental research and for adequate dental service for indigent natives."

(2) *Resolved* that we endorse the following statement: 'The American Association for the Advancement of Science, recognizing the important rôle of animal experimentation in the study of diseases, especially those of childhood, and in the perfecting of those procedures and treatments to which no small part of our community owes its life and continued presence among us, regards with apprehension the activities of certain groups which are attempting to prevent the use of unclaimed animals for study in qualified institutions of medicine and research and which are endeavoring by direct and indirect means to cut off the supply of animals needed in the production of antitoxins and other biologic products. This Association is in accord with the practically unanimous and often expressed authoritative voice of science and medicine that animal experimentation has conferred inestimable benefits upon mankind, as well as upon animals themselves, and is essential to the progress of the biological and medical sciences. This Association, with a membership of over eighteen thousand and representative of all the sciences of nature and of man, is confident that a fully informed public will not support legislation which would seriously interfere with the progress of preventive and curative medicine.' "

The Secretary was authorized to express Association's appreciation of courtesies and coöperation received from Local Committee on Arrangements representing the Minnesota Section, and from management of the Hotel Nicollet.

The 28 nominees for membership, listed on page 343, were presented as eligible for election.

WILLIAM J. GIES,
*General Secretary.*

*Addendum*

The foregoing acts of the Council were approved by subsequent vote of the Association, including election of all nominees for membership and adoption of the two resolutions.

*Treasurer's* report received and referred for audit to committee of N. Y. Section. Income exceeded expenses.

*Trustees of Endowment Fund* reported no substantial increase above last report. (March 5, 1937, $1,205.72). Referred to committee of members of N. Y. Section for audit. Recommendations for method of handling funds approved. Recommendations to combine endowment funds laid on table for further consideration.

*Tellers* (Drs. Boucher, Bryan and Blayney) reported vote electing officers listed on page 343; also reported Council authorized to ratify elections of nominees of sections outside of North America (page 343). These elections have been subsequently confirmed. Ballots received from following members:

Aisenberg, Anderson (B. G.), Arnim, Armstong, Bagnall, Bear, Best, Bier, Berger, Bibby, Blayney, Bodecker, Boucher, Bradel, Brand, Brandhorst, Brashear, Brawley, Brekhus, Broadbent, Brodsky, Bryan, Bryant, Bunting, Burket, Carr, Chase, Cheyne, Churchill, Clark, Clough, Cook, Cowling, Cox, Crane, Darlington, Dean, de Jonge-Cohen, Denton, Dobbs, Dressel, Driak, Dunning (W. B.), Easton, Ellis, Erikson, Fleming, Friesell (H. R.), Freeman (C. W.), Gies, Goodsell, Gottlieb, Grossman, Hackh, Hall, Hanzlik, Harvey, Hatton, Hess, Higley, Hill, Hine, Hodge, Husband, Hutchinson, Ivy, Karshan, Kazanjian, Keilty, Kelsey, Kitchin, Kesel, Klaffenbach, Klein, Korkhaus, Krasnow, Krogh, Krogman, LeFevre, Lefkowitz, Leonard, Lewis, Lisscher, Loos, Lowery, Lundquist, Lynch, Marshall, McBride, McCall, McCrea, McDonagh, McFarland, McKay, Meisel, Merritt, Millberry, Miner, Moore, Morse, Mueller, Myers (R. E.), Myers (V. C.), Naprstek, Neuwirth, Neustadt, Noyes (H. J.), Oartel, Orban, O'Rourke, Oxner, Paffenbarger, Palazzi, Palmer, Pichler, Podolin, Price, Prinz, Proell, Rehak, Rickert, Robinson, Rosebury, Rule, Salamon, Schönbauer, Schoonover, Schour, Schroff, Sedwick, Skillen, Skinner, Smith (M. C.), Sprawson, Souder, Stephan, Stone, Swanson (W. F.), Sweeney, Taber, Tainter, Taylor (N. O.), Taylor (R. M. S.), Taylor (W. E.), Thoma, Tiblier, Trimble, Tunnicliff, Van Huysen, Van Kirk, Varga, Wach, Waite, Waldron, Waugh, Welker, Willett, Willman, Wolf (H.), Wolfe (F. J.), Worman, Wheeler, Wright, (G. H.). Total—163. (Adopted).

B. JOURNAL OF DENTAL RESEARCH

*a. Committee on Endowment*

Report read by Dr. L. M. Waugh in absence of Dr. Merritt, chairman. This year's activities along two lines: *First*, planned to create endowment fund of approximately $50,000 by personal letters to key

persons. Response gratifying as pledges amounting to about $18,000, more than half of which is paid. *Second*, effort has been made to substantially increase number of subscribers to the JOURNAL. Continued success of the JOURNAL depends upon number of subscribers, rather than upon size of any endowment fund. This is highly important and should be and is, one of main objectives of committee having matter in hand. Adopted and referred to committee of members of New York Section for audit.

### *b. Publication Committee*

Treasurer reported income for 1937 at $5,470 (approximately), broken up into subscriptions, $2,870; advertising, $1,000; A. D. A. grant, $600; and A. C. D. grant, $1,000. Advertising manager reported actual collections for 1937 of $1,026.65, balance due, $343., total estimated receipts from advertising, $1,369.65. Circulation manager's report covered in great detail all matters pertaining to circulation. Nearly all members of Association are subscribers. It was urged that every effort be made to increase circulation. Reports accepted and referred to committees of members of Sections in Rochester, Richmond, Baltimore and St. Louis for audit.

Majority of Publication Committee (Robinson, Hall, McCrea) suggested reduction of Committee to 3 members (Editor, Business Manager, Circulation Manager) and election of same for two year term. Assistants to be appointed by elected officers. Minority (Hodge, Hine) approved with advice two associate editors be created.

### *c. Board of Editors*

Prior to meeting voted by correspondence to modify present Committee and reduce to 3 responsible members (Managing Editor, Business Manager, Circulation Manager). At meeting of March 12 recommendations of majority of Publication Committee accepted without placing any time for duration of appointments. Whole report to be referred to Council. Also discussed feasability of enlarging Committee with two Associate Editors; enlarging Board with two members-at-large and handling all JOURNAL funds in one account. Work of Publication Committee highly praised and commended. Resignation of Secretary J. L. T. Appelleton noted.

### C. MISCELLANEOUS TRANSACTIONS

*Resolutions of appreciation.* Secretary instructed to express, to management of Hotel Nicollet, to Minneapolis Section, to Dr. Worman, chairman of the local-arrangements committee, to Dean Lasby and his colleagues, Association's appreciation of hospitality and coöperation accorded to Association in general and to members individually, especially in view of local conditions referred to previously.

### D. LIST OF OFFICERS AND NEW MEMBERS ELECTED

#### *a. Officers (1938–39)*

HONORARY: *Vice-presidents*—KAREL ČERNÝ, Prague. J. LEWIN PAYNE, London. A. MARTIN SCHWARZ, Vienna. J. C. MIDDLETON SHAW, Johannesburg. HARRISON J. MULLETT, Chengtu.

ACTIVE: *President*—THOMAS J. HILL, Western Reserve University. *President-elect*—WILLIAM J. GIES, Columbia University. *Vice-president*—RUDOLF KRONFELD, Loyola University (Chicago). *Treasurer*—BISSELL B. PALMER, N. Y. Polyclinic Medical School and Hospital. *Secretary*—EDWARD H. HATTON, Northwestern University. *Trustee of the Endowment Fund* (three years)—ARTHUR H. MERRITT, New York City.

#### *b. New members*[1]

*Ann Arbor, Mich.* MARY C. CROWLEY, A.B., M.S., D.P.H., Research Assoc. in Dental Bacteriology, and KENNETH R. EASLICK, A.B., D.D.S., M.S., Ass't. Prof. of Children's Dentistry, Dental School, University of Michigan.

*Chicago, Ill.* CAROLYN HAMMOND, B.S., A.M., Research Tech., OSCAR KANNER, M.D., Research Assoc., and MAURINE WILLMAN, B.A., Research Tech., Foundation for Dental Research, Chicago College of Dental Surgery (Loyola Univ.). R. WENDELL HARRISON, A.B., M.S., PH.D., Ass't. Prof. of Bacteriology, FRANK F. KANTHAK, B.S., D.D.S., M.D., Instr. in Dental Surgery, and BENJAMIN F. MILLER, S.B., Ch.E., M.D., Ass't. Prof., Zoller Memorial Dental Clinic; and ARNO B. LUCKHARDT, M.S., Ph.D., M.D., Sc.D., LL.D., F.A.C.D., Prof. of Physiology, Univ. of Chicago.

*Columbus, Ohio.* WILLIAM C. GRAHAM, D.D.S., F.A.C.D., Prof. of Oral Medicine, Ohio State Univ.

*London, England.* HUMPHREY F. HUMPHREYS, O.B.E., M.C., T.D., D.L., M.B., Ch.B., M.D.S., K.H.P., Prof. of Dental Surgery, Univ. of Birmingham.

[1] A list of the members, as of December 1, 1937, was published in the *J. Den. Res.*, **16**; 562, 1937. A list of the members elected in 1937 was published in the *J. Den. Res.*, **16**; 364, 1937.

*New York, N. Y.* GERRIT BEVELANDER, A.B., M.S., Ph.D., Instr. of Anatomy, and ALLEN T. NEWMAN, M.S., D.D.S., Dean, Dental School, New York University. HOUGHTON HOLLIDAY, B.A., D.D.S., Assoc. Dean, BENJAMIN TENENBAUM, B.S., D.D.S., Research worker, Den. Sch., Columbia University. EDITH B. OBLATT, Ass't. Laboratorian, Guggenheim Dental Clinic. JACOB A. SALZMANN, D.D.S., Director, Dental Service, New York City Vocational Schools. DAVID TANCHESTER, D.D.S., Attending Dentist, Montefiore Hospital.

*Providence, R. I.* ALBERT L. MIDGLEY, D.M.D., Sc.D., F.A.C.D., Chairman, Com. on Research, Amer. Coll. of Dentists.

*Rochester, N. Y.* MARTIN L. DEAKINS, B.S., M.S., D.D.S., EDWARD HAMPP, D.D.S. (Visiting Fellow from Washington University, St. Louis) and JOSEPH F. VOLKER, D.D.S., Carnegie Fellows in Dental Research, Univ. of Rochester.

*St. Louis, Mo.* LEROY R. BOLING, A.B., M.S., Ph.D., Ass't. Prof. of Anatomy and Histology, and WILLIAM E. KOCH, JR., D.D.S., Instr. in Dental Radiography, Dental School, Washington Univ.

*Toronto, Canada.* ARNOLD D. MASON, D.D.S., F.A.C.D., Dean, Dental School, Univ. of Toronto.

*Washington, D. C.* J. E. ASH, M.D., Lieut. Col., Medical Corps, U. S. Army, and LEROY P. HATLEY, Lieut. Col., Dental Corps, U. S. Army, Army Medical Museum, Washington, D. C. JOHN R. BEALL, B.S. in Mech. Engr., A.D.A. Research Assoc., National Bureau of Standards.

*Total number of new members*, 28.

*Total active membership (June 30, 1938)*, 449

### E. MEMBERS PRESENT AT ONE OR MORE SESSIONS

SECTIONS. *Ann Arbor:* Bunting, Jay, Rickert, Ward. *Baltimore:* Aisenberg, McCrea, Robinson. *Boston:* Cushman, Jump, Marjerison, Miner, Morse, Trimble. *Chicago:* Blayney, Bradel, Claflin, Coolidge, Denton, Fosdick, Freeman, Harrison, Hatton, Hine, Kanner, Kesel, Kronfeld, Logan, Noyes (F. B.), Noyes (H. J.), Schour, Skillen, Skinner, Tunnicliff, Willman. *Cleveland:* Hill. *Columbus:* Boucher, Dottrell Graham, Kitchen, Semans. *Detroit:* Lane. *Iowa City:* Bryan. *Louisville:* Myers, O'Rourke. *Minneapolis:* Armstrong, Best, Brekhus, Cohen, Epstein, Gardner, Schram, Taylor, Vehe, Wahlquist, Waldron, Worman. *New Haven:* Arnim, Burket (both waiting transfer to other sections). *New Orleans:* Tiblier. *New York:* Bevelander, Bodecker, Crawford, Gies, Holliday, Lefkowitz, Newman, Waugh. *Philadelphia:* Churchill, Cook, Turner. *Pittsburgh:* Friesell (H. E.), Wright. *Richmond:* Bear, Gurley, Hall. *Rochester:* Bibby, Brawley, Cheyne, Deakins, Hampp, Hodge, LeFevre, Manly, Sedwick. *St. Louis:* Boling, Brandhorst, Lischer, Robinson. *San Francisco:* Shell, Tainter. *Toronto:* Mason. *Washington:* Krogh. *No section:* Klein (Washington), Midgley (Providence). Total 94. (All U. S. Sections represented in attendance.)

# WILLIAM J. GIES ENDOWMENT FUND

## Compiled by LEUMAN M. WAUGH, Treasurer

### FINANCIAL STATEMENT AS OF MAY 10, 1938

| | | |
|---|---|---|
| Total receipts | | $11,056.19 |
| Disbursements: | | |
| Transfer of subscriptions to the office of the Journal of Dental Research | $395.00 | |
| Expenses | 134.06 | 529.06 |
| Balance | | $10,527.13 |
| Pledged, but not received May 10, 1938 | | 9,567.50 |
| Total cash and pledges | | $20,094.63 |

### WILLIAM J. GIES ENDOWMENT FUND[1,2]

| Class | Name | Address | Pledge | Amount Paid |
|---|---|---|---|---|
| *Benefactor* | | | | |
| $1000 up | American College of Dentists | | $5000 | |
| | Chicago Dental Society (Bal. promised 7/1/38) | Chicago, Ill. | 1500 | $750 |
| | Arthur H. Merritt | New York | 1000 | 1025 |
| | N. Y. Academy of Dentistry; G. S. Callaway, Treas. | New York | 5000 | 3500 |
| | Leuman M. Waugh ($200 yearly) | New York | 1000 | 200 |
| *Patron* | | | | |
| $500 to $1000 | Dental Society of State of N. Y. | | 500 | |
| | First District Dental Society; John L. Peters, Secy. | New York | | 500 |
| | Illinois State Dental Society | Rock Island, Ill. | | 700 |
| | Albert L. Midgley | Providence, R. I. | | 500 |
| | Michigan State Dental Society (payments $100 yearly) | Ann Arbor, Mich. | 500 | |
| *Donor* | | | | |
| $250 to $500 | G. C. Paffenbarger ($25 yearly) | Washington, D. C. | 250 | 50 |
| | Virginia State Dental Society; J. E. John, Secy.-Treas. | Roanoke, Va. | | 250 |

[1] List made up as of May 10th, 1938.

[2] Leuman M. Waugh, Treas. All amounts of Ten Dollars and less are for subscriptions to the Journal of Dental Research and were forwarded to Dr. M. W. McCrea, Lombard & Greene Sts., Baltimore, Md.

*Goodwill Contributor*

| | | | | |
|---|---|---|---|---|
| Amts to $250 | Alpha Omega Fraternity; Wm. Rich, Supreme Scribe | Bronx, N. Y. | | 100 |
| | Arkansas State Dental Society; I. M. Sternberg, Treas. | Fort Smith, Arkansas | | 100 |
| | Atlantic Orthodontic Society; (Received through H. S. Smith, Treas.) | Chicago, Ill. | | 20 |
| | Dr. D. J. Aubertine | San Francisco, Calif. | | 20 |
| | Dr. A. W. Bryan | Iowa City, Iowa | | 50 |
| | California State Dental Society; F. T. West, Secy. | San Francisco, Calif. | | 100 |
| | Cincinnati Dental Society; S. A. Schmid, Secy. | Cincinnati, Ohio | | 200 |
| | Conn. State Dental Asso.; C. W. Vivian, Secy.-Treas. | New Britain, Conn. | | 100 |
| | Foundation for Dental Research of Chicago College of Dental Surgery; Dr. W. H. G. Logan, Chairman | Chicago, Ill. | | 100 |
| | Fox River Valley Dental Society; K. L. Klaver, Secy. | Oshkosh, Wis. | | 100 |
| | James Allen Graham | San Francisco, Calif. | | 50 |
| | Hudson County Dental Society; Alton L. Fisher, Secy. | Woodcliff, N. J. | | 200 |
| | Iowa State Dental Society; John Scholten, Secy. | Cedar Rapids, Iowa | | 100 |
| | Dr. Arthur R. McDowell | San Francisco, Calif. | | 20 |
| | Nevada State Dental Asso.; Harold Cafferata, Secy. | Reno, Nevada | | 30 |
| | Oregon State Dental Asso.; H. C. Fixott, Secy. | Portland, Oregon | | 50 |
| | Dr. T. C. Purcell | St. Louis, Mo. | | 50 |
| | Richmond Dental Society | Richmond, Va. | | 100 |
| | San Francisco Dental Asso. | San Francisco, Calif. | | 100 |
| | Texas State Dental Society; W. W. Ogle, Treas. | Dallas, Texas | | 100 |
| | Waterloo District Dental Society; A. M. Raecker, Treas. | Waterloo, Iowa | | 50 |
| | Wisconsin State Dental Society | Madison, Wis. | | 100 |
| *Life* | | | | |
| $100 | Dr. O. W. Brandhorst | St. Louis, Mo. | | 100 |
| | Dr. Geo. S. Callaway | New York | 100 | 50 |
| | Dr. S. Ellsworth Davenport | New York | 100 | 50 |
| | Dr. Wm. B. Dunning | New York | 100 | 25 |

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|---|---|---|---|---|
| | Dr. John E. Gurley (bal. during 1938) | San Francisco, Calif. | 100 | 37.50 |
| | Dr. Oborn G. L. Lewis | Phila., Pa. | | 100 |
| | Dr. B. E. Lischer | St. Louis, Mo. | 100 | 25 |
| | Dr. William A. Spring | New York | | 150 |
| | Dr. F. C. Cole | New York | | 100 |
| | Dr. Martin C. Tracy | New York | | 100 |

*Endowment*

| | | | |
|---|---|---|---|
| $25 | Dr. Jos. P. Arnold | Houston, Texas | 25 |
| | Arizona State Dental Society; P. K. Hill, Tr. | Tuscon, Arizona | 25 |
| | Calumet County Dental Society; J. E. Reinbold, Secy. | Chilton, Wis. | 25 |
| | Dr. George Wood Clapp | New York | 25 |
| | Eta Eta Chapter, O. K. U.; C. A. LeMastor, Tr. | St. Louis, Mo. | 25 |
| | Faculty of Dental School, Marquette University, R. G. Houkohl, Secy. | Milwaukee, Wis. | 25 |
| | Fond du Lac County Dental Society; H. C. Hahn, Secy. | Don du Lac, Wis. | 25 |
| | Fort Dodge District Dental Society; S. F. Holaday, Treas. | Webster City, Iowa | 25 |
| | Dr. H. D. Grubb | Cleveland, Ohio | 25 |
| | I. A. D. R., Chicago Section; Edgar D. Coolidge | Chicago, Ill. | 25 |
| | I. A. D. R., New York Section; I. Neuwirth, Treas. | New York | 25 |
| | Dr. E. A. Johnson | Boston, Mass. | 25 |
| | Kings County Dental Society | Brooklyn, N. Y. | 25 |
| | Marquette University Dental Alumni Association | Milwaukee, Wis. | 25 |
| | Milwaukee County Dental Society; A. T. Doheman, Treas. | Milwaukee, Wis. | 25 |
| | Dr. A. L. Nygard | Texas | 25 |
| | Dr. J. Clarance Salvas | Phila., Pa. | 25 |
| | Dr. W. H. Scherer | Houston, Texas | 25 |
| | Dr. Edward B. Spalding | Birmingham, Mich. | 25 |
| | Dr. Alfred Walker | New York | 25 |
| | Dr. J. Richard Walsh | East Orange, N. J. | 25 |
| | Winnebago County Dental Society | Berlin, Wis. | 25 |
| | Xi Chapter O. K. U. (Marquette University Dental School; Dr. J. W. Quasney, Treas.) | Milwaukee, Wis. | 25 |
| | Dr. Oscar J. Chase, Jr. | New York | 25 |

## CORRECTION

In the article by Dr. R. M. Stephan, entitled "Hydrogen Ion Concentration of the Dental Plaque," in the June issue (*J. D. Res.*, 17: 251, 1938) the first sentence on page 252 should read "The volume of the plaque was seldom greater than *1 cubic millimeter* when removed from the surface of the tooth." Under "Materials and Methods," on page 252, the seventh line in paragraph three should read "*1 cubic millimeter* was placed over each portion of the plaque. . . ."